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How Will the World End?

WHAT will the end of the world be like? In the Fels Planetarium of the Franklin Institute at Philadelphia, recently, thousands of persons witnessed a preview of this spectacle, the most gripping that man will ever see. "Canned" sound effects from great electrical storms added realism to the thrilling images of cosmic cataclysms thrown on the planetarium dome by a giant projector to dramatize four possible ways in which life on our planet may be destroyed—by burning, collision, freezing, and explosion. Paintings reproduced in these pages show the tragic scenes they suggest.

Sometimes a star becomes a "nova," or mysteriously flares up in brightness. Suppose that suddenly our own star, the sun, should likewise act as if a vast bellows were blowing a draft into its molten interior. In eight brief minutes the resulting blast of radiant heat would reach the earth, and all life on this planet would vanish in clouds of steam and puffs of smoke. Fortunately, however, the chances of such celestial fireworks are remote. The sun probably was a nova when the solar system was born and is unlikely to repeat the performance.

Instead, however, the sun might undergo only a twofold or threefold rise in temperature, as astronomers have seen happen to a star in the constellation of Cassiopeia. A few more degrees here would bring a slower but no less inevitable end. Polar ice would melt, and the ocean would rise 200 or 300 feet, destroying great coastal cities. The rising temperature would draw more moisture into the air. Constant storms would rack the world. Finally life would succumb to the steamy, superheated atmosphere.

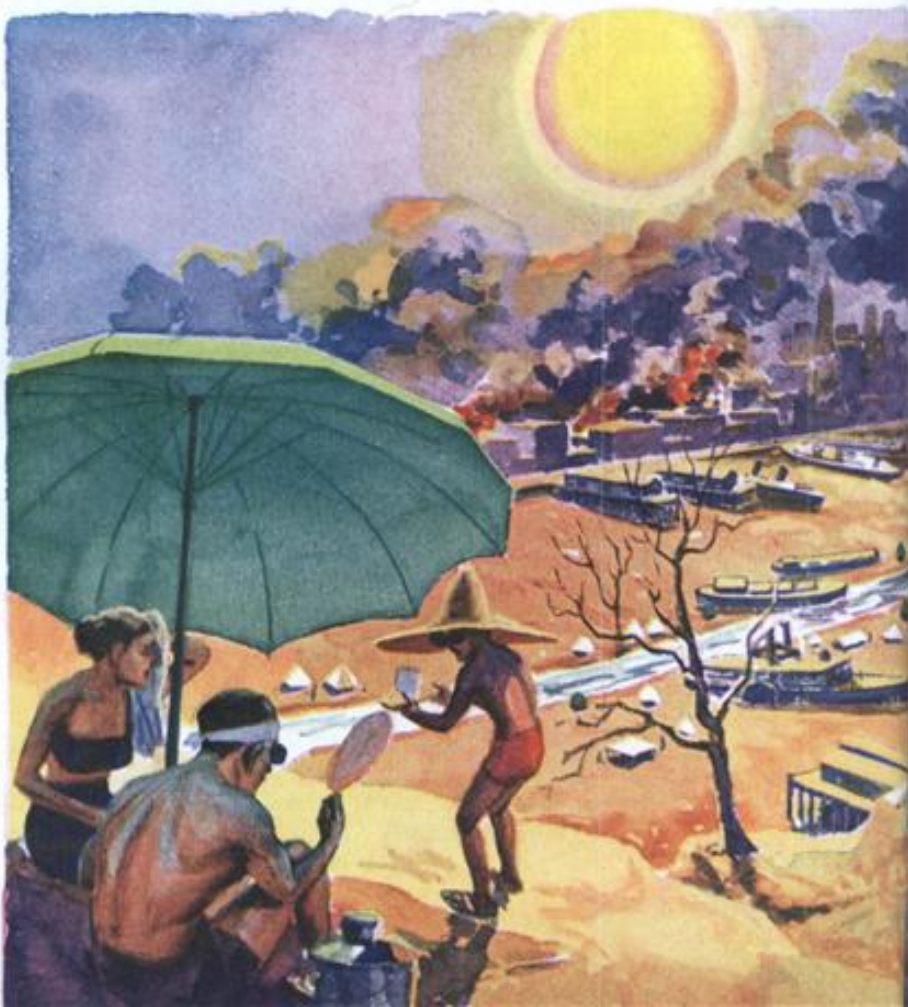
When the planetoid Hermes whizzed past the earth in October, 1937, it suggested another accidental way that at least a large part of the world's population may be wiped out. A newly discovered stray from a remote cluster of "baby planets," Hermes missed us by the uncomfortably close mar-

gin of less than 400,000 miles, or not much more than the distance to our own moon. Traveling at 70,000 miles an hour, the sky projectile was less than six hours' flight away from us at its nearest point! It was the earth's narrowest escape from a major crash in the history of astronomical observation.

Hermes ranks as one of the smallest of the known planetoids, measuring only a mile or so in diameter, and the earth might suffer little more than a violent jolt if the baby planet hit an uninhabited land area. In case it landed in an ocean, however, devastation by tidal waves would be appalling. And if it struck a crowded metropolitan area, the toll of life would equal that of a world war. People that it missed would still be threatened, not only by terrible earthquakes, but even more by a searing air blast of hurricane velocity that would mushroom out from the point of impact. Acting as a piston to compress the atmosphere against the earth's surface, the planetoid would heat it like air in a tire pump, scorching to a crisp anything in the vicinity.

Such a phenomenon was observed on a smaller scale in 1908, when a swarm of meteorites—really the head of a small comet—struck the earth (*Continued on page 222*)

BURNING. If the sun grows hotter, life will perish in the superheated atmosphere





COLLISION. A giant meteor, running wild through space, may strike the earth and spread havoc with its impact and scorching breath

EXPLOSION. The moon draws nearer the earth, raising enormous tides and unleashing the inferno seething beneath its crust

DRAWINGS BY B. G. SEIELSTAD



FREEZING. As the sun burns out, ice will cover the earth and men will shiver around fires in dark caverns



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How Will the World End?

(Continued from page 58)

in a sparsely settled region of Siberia. The accompanying blast of air flattened forests, bowled over persons 100 miles away, and circled the earth twice before all its force was spent. Suppose a few hours' difference in time had brought the fireballs down in Leningrad, Stockholm, or Copenhagen!

A more certain finish, although lying billions upon billions of years ahead of us, is freezing. Feeding upon itself to create energy, the sun is constantly losing weight. Sooner or later it will be completely burned out—a dead power plant.

As that time approaches, the sun will become a dull-red ball in a sullen sky, casting only a feeble, ruddy glow over ice that will cover the earth. For a time, human beings will be able to live near the equator, and then underground, beside perpetually burning fires. But when the solar furnace dwindles to a faint spark, the earth's atmosphere will turn to liquid air and life will become impossible.

Another event will make doubly certain of the world's end, in the almost inconceivably distant future. As tidal friction slows down the moon in its orbit, the earth will draw it nearer and nearer. To anyone still on earth, it will appear as an ominous golden-orange orb, fattening in apparent size until it reaches twenty-four times its present magnitude—no longer a friendly beacon by night, but a terror in the skies.

Its approach will set up terrific tides in the earth's seas. At high water, the oceans will wash over all but the highest mountains. Racking strains in the earth's crust will unleash the inferno that lies beneath, and volcanoes will spew smoke, lava, and poisonous gases into the air.

Finally the moon will get too close. The earth will set up irresistible "land tides" in its solid satellite. Since the moon cannot give, it will burst—first in two, then in smaller pieces. Some of these will rain on the earth as showers of molten meteors, completing the destruction of anything alive. The rest will revolve around the earth, forming a beautiful band of light like Saturn's rings. But no living thing will be here to see it.

There remains a more hopeful side to the picture. Man, if still the dominant creature here, clearly will have seen the planet approaching its inevitable doom. Long before the end comes, may he not have devised a way to flee—perhaps in rocket ships—to some more hospitable planet? He need not hurry his preparations; for, barring accidents, he has quite a few billions of years left to think about it and decide what to do.

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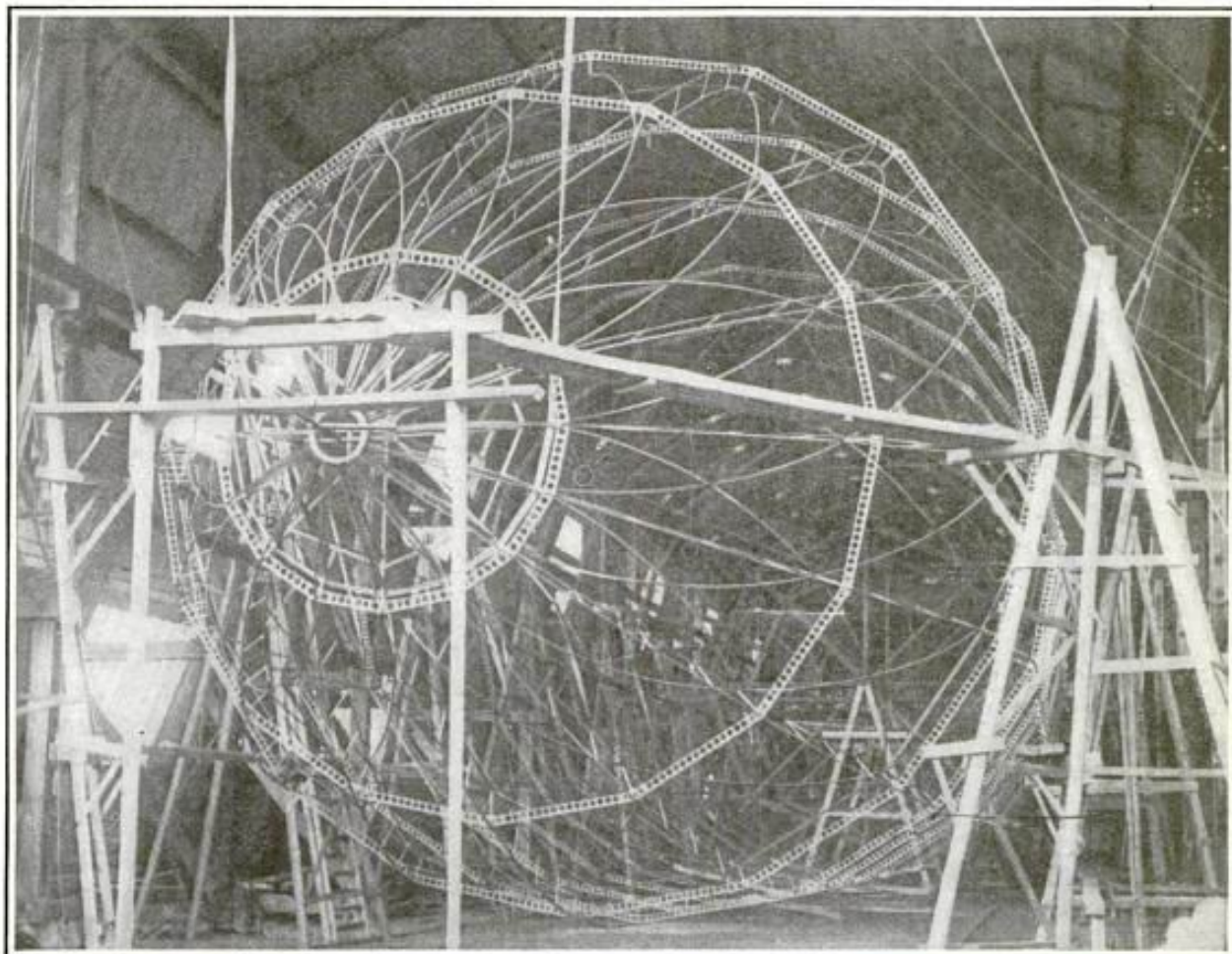
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A Pigmy Zeppelin

A PIGMY Zeppelin (pigmy as Zeppelins go) with a basket-work frame of layered wood has been recently built for the British Government by a number of American constructors, including T. Rutherford Mac-Mechen, president of the Aeronautical Society of America, and Walter Kamp, a prominent American aeronautical designer.

One of the chief efforts of the designer has been to reduce the weight of the hull

and car without sacrificing strength, and this has been accomplished, he believes, by the substitution of laminated wood for the aluminum which composes the framework of the Zeppelin. The rings which are used to keep the hull in cylindrical form are made of thirty-nine thin layers of mahogany, carefully glued together, and covered by a steel collar. Thirty-two wooden ropes, hardly as thick as a man's thumb, wind again and again around the hull, weaving the whole



A pigmy Zeppelin which is being built for the British Government by a company of American constructors. The framework of this novel airship is made of ropes and laminated wood, so closely woven together as to resemble a huge mesh of wood and wire

into a great mesh of basket-work. Sixteen slender members form the longitudinals, running from bow to stern, and intersecting the spirals of wooden rope where they cross each other. The function of the spirals and longitudinals acting together is to distribute the gas lift and strains evenly to all points of the hull.

There are, in reality, two hulls, the inner enclosing thirteen balloonets or gas bags and the outer supporting a waterproof and airtight envelope or skin. Twenty-nine ribs, or transverse girders, encircle the inner hull, and a spider web of wire cables stiffens the alternate ribs and forms the bulkheads between the balloonets.

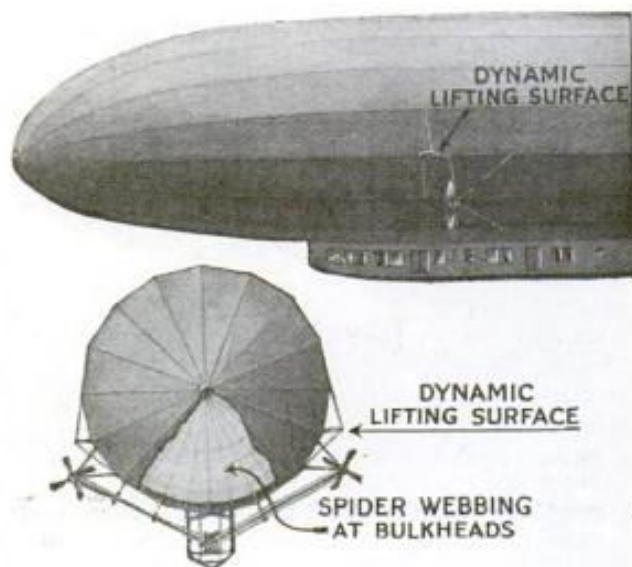
Two eight-cylinder, sixty-horsepower motors have been installed, and by means of cable drives transmit the power to four propellers mounted high above the car, two being placed on each side of the slender torpedo-like hull.

In hot weather, or when the airship passes through a heated stratum of air, the gas expands, exerting more lifting power, and causing the airship to rise. To control this tendency, the gas has to be artificially cooled, or it will be necessary to release some of the valuable hydrogen to allow the ship to retake its proper altitude. On the contrary, if a sudden wave of cold air strikes the gas bag, the gas immediately contracts, and part of its lifting power is lost. If there is no means for heating the gas and expanding it, ballast will have to be dropped from the car, thus compensating the decreased lifting power of the gas by a lighter weight which it has to carry.

The control of the lifting power of the gas in the MacMechen dirigible is in the heating and cooling process. To keep the hydrogen from cooling and losing its lifting power, hot vapor from the engine is blown into the foot-wide space between the balloonets and the outer skin of airtight cloth. To cool and condense the gas for descent, or to prevent its expansion to an extent that causes an undue inflation of the gas bags, cold air is introduced into the same space by means of a luminum disks with revolving shutters at the bow and stern.

It is claimed that by this method of

construction a rigid airship has been built which is one-third lighter than it is possible to build a Zeppelin of the same relative size. The hull and car weigh 2,190 pounds, and the gas capacity is 108,000 cubic feet, or about one-tenth that of the latest Zeppelin monster. As hydrogen is usually rated by aeronauts, this quantity will lift about three and one-half tons, or seven thousand pounds. With engine equipment and crew, the airship weighs about 5,300 pounds, leaving a margin of 1,800 pounds for ballast, explosives and additional fuel. The length of the hull is 236 feet over all. The designers claim that their airship



will make about seventy miles an hour, or about ten miles an hour faster than the speed of a Zeppelin.

The POPULAR SCIENCE MONTHLY believes that this airship will prove disappointing to its builders and to the British Government. Previous experiments with wooden frames in dirigibles have proved costly failures. The Zeppelin's first rival, the Schütte-Lanz dirigible, was built with wooden framework, and proved much heavier than a Zeppelin of the same dimensions. Laminated wood was used in the experiment and this was found faulty and discarded. The Zeppelin of to-day is the product of practical experience, as is the second, and successful, Schütte-Lanz, which discarded the weblike wooden frame for the lighter metal ribs and strakes of the Zeppelin. Such a solid frame as that of the pigmy airship would not do for a

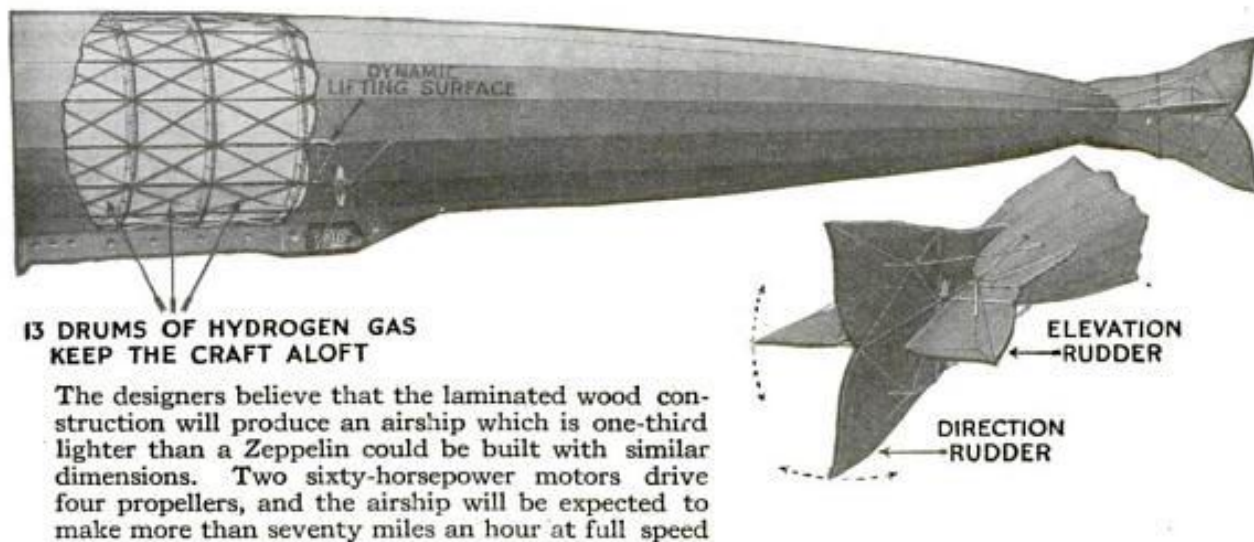
larger dirigible, for it loses the greater lightness for the same strength of a small structure. In a small dirigible resistance against propulsion is so much greater than the lift available for engine power in the large craft, that it completely discounts the small craft's structural advantages. Any improvements in lightness and strength will, therefore, never make this pigmy Zeppelin a superior in speed to its larger and more powerful rival.

The whole idea of a small and speedy "aerial destroyer" is mistaken, since in a dirigible everything has to take second place to speed; otherwise Zeppelins,

crease the lifting power, and consequently the size, in order to achieve greater power and speed. Whether the Zeppelin has been a success or not is a mooted point, but the Zeppelin has been the only dirigible that has accomplished anything of note in this war, and the smaller dirigibles have been permanently relegated to their hangars.

A Barbed-Wire-Proof Fabric

ONE of the most trying tasks incident to trench fighting has been considerably lightened by the appearance in the British trenches of gloves made of a fabric which is said to be impervious to



which cannot seek safety in landing, would be at the mercy of the wind.

The rope drive to the propellers has been proved greatly inferior to bevel gearing, chains and belts. The cable drive was tested on the first Gross-Basenach, but was quickly discarded.

The most meritorious feature of the design of the pigmy Zeppelin is in the alternate heating and cooling of the gases by hot vapor from the engine and cool air sucked in by blowers. This certainly should prove of valuable assistance to the dynamic lift-control without entailing much additional weight.

In conclusion, it seems that the idea of a wooden frame has been tried, approximately in its present form, and found lacking. The rope drive has been succeeded by more efficient means of power transmission, and the entire trend of dirigible construction has been to in-

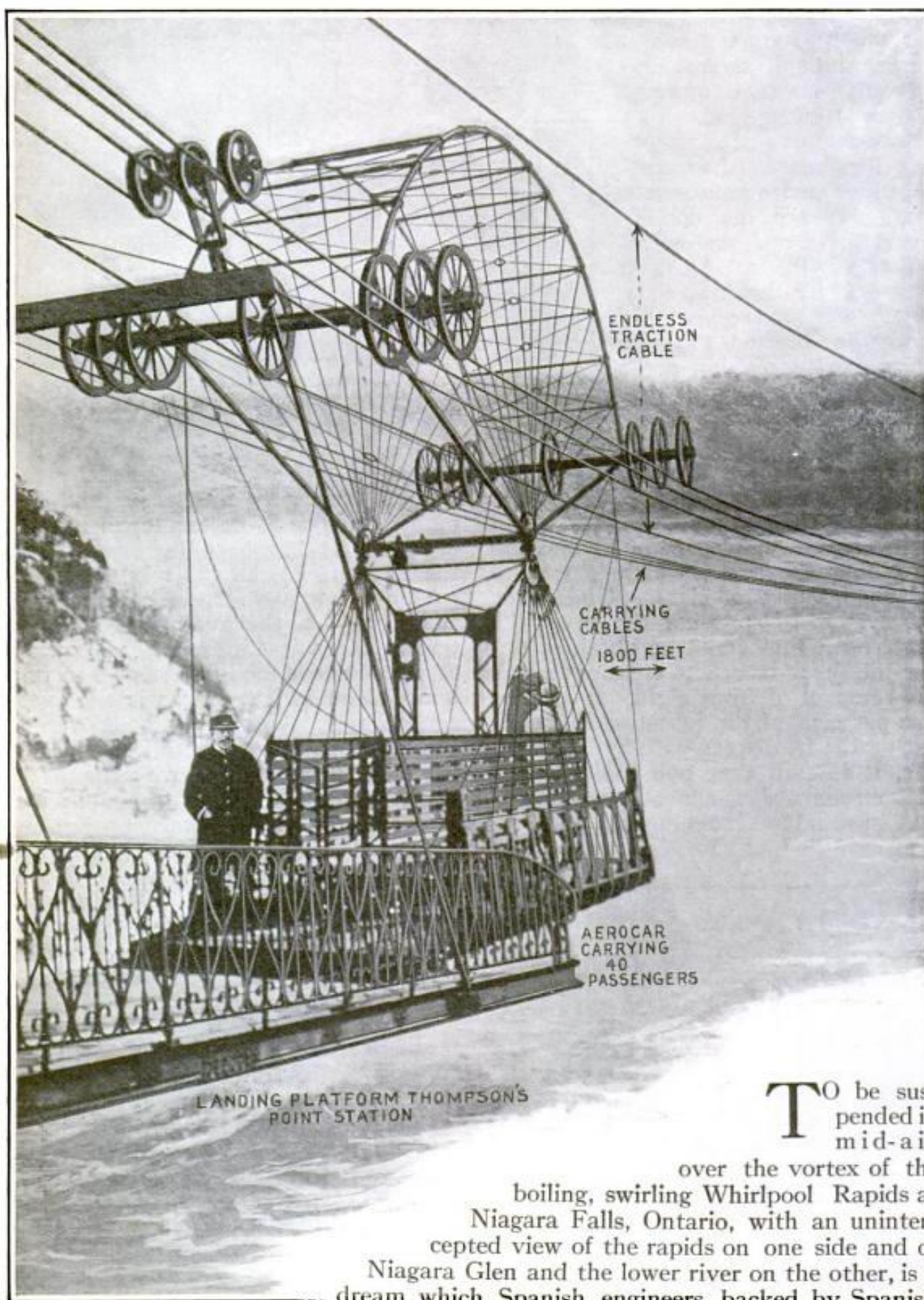
barbed-wire points. The fabric is made up into mittens, with the first finger and thumb separate. The fabric is waterproof, and in addition the gloves are insulated for gripping electrically-charged wires.

The same material is applied to the manufacture of sleeping-bags, which, when opened, may be thrown over a barbed-wire entanglement to allow a soldier to climb over the sharp points without injury. When made up into vests or tunics, the fabric is strong enough to turn shrapnel splinters, or even a bullet when it has lost part of its momentum. The interlining is antisepticized, so that if a bullet goes through, it takes into the wound enough antiseptic wool to prevent poisoning.

The materials used in the manufacture of this remarkable fabric have been sedulously kept secret this far.

Niagara's New Air Route

By Charles W. Person



TO be suspended in mid-air over the vortex of the boiling, swirling Whirlpool Rapids at Niagara Falls, Ontario, with an uninterrupted view of the rapids on one side and of Niagara Glen and the lower river on the other, is a dream which Spanish engineers, backed by Spanish

capital and patents, have realized. An aerial scenic cableway now spans the Rapids from cliff to cliff.

For sheer excitement and thrill the

It was the successful operation of the San Sebastian cableway, for the past six years, during which time it carried as many as twenty-six thousand passen-



trip by air over the Whirlpool outdoes anything that tourists have ever experienced. True, there is the first stage of the cableway which climbs the Wetterhorn in Switzerland; but it can not compare in magnitude with the Niagara project. Then there is the tramway at San Sebastian, Spain, for the transportation of tourists from a trolley terminus to a casino overlooking the Bay of Biscay—the only previous installation of the system in use at Niagara Falls and owned by the same company. But, the span at San Sebastian is only nine hundred and nineteen feet, while at Niagara it is eighteen hundred feet. It may be safely said that Niagara now has the longest and probably the safest scenic cableway in the world.

gers in a single season, which brought Torres y Quevedo, the inventor of the system, to Niagara Falls. No time was lost in starting operations. Work was begun July 12, 1915. The cables are now erected, and cars are now running upon them.

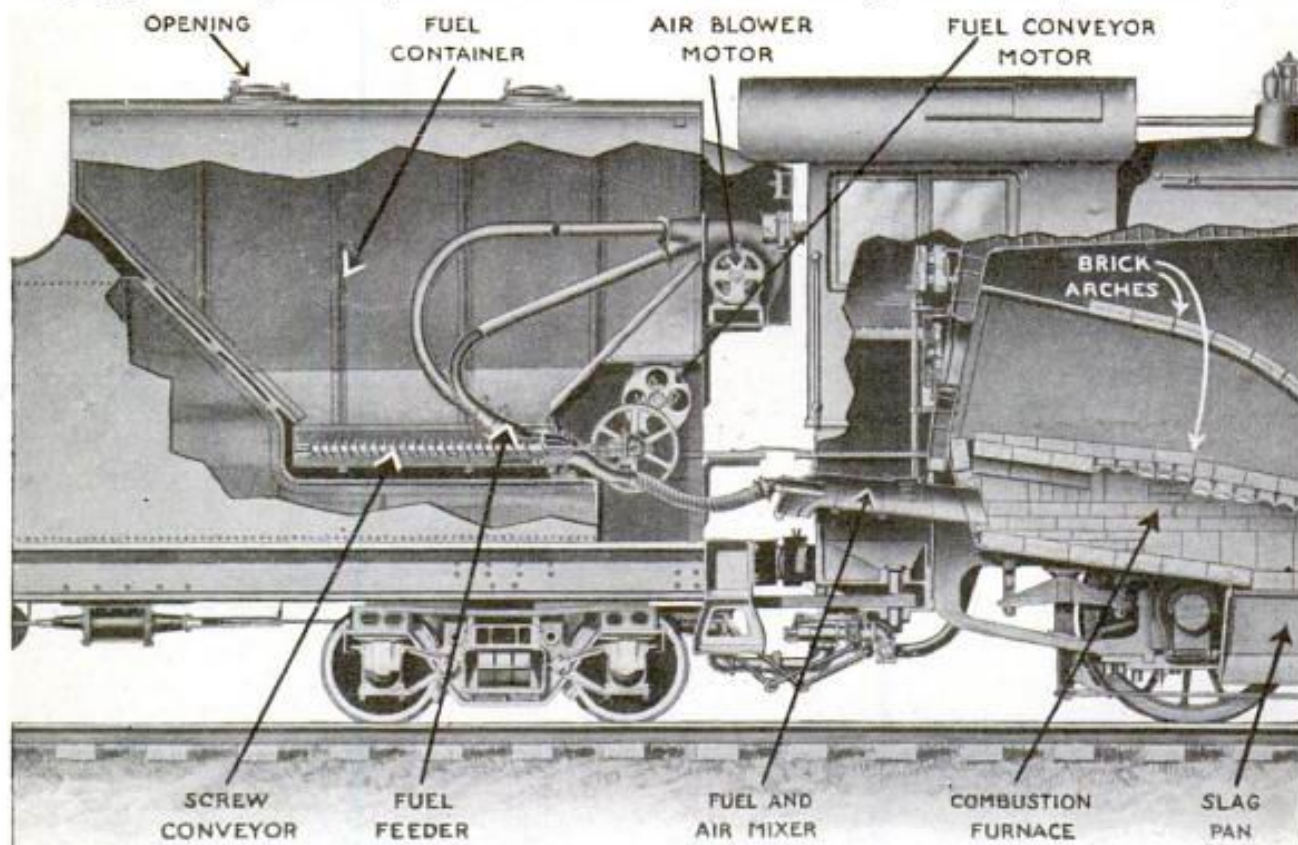
Diplomacy and Engineering

The Whirlpool is situated some three miles below the Falls and is almost entirely within Canadian territory. Hence, the two anchorages or terminals of the cableway, Colt's Point and Thompson's Point, are both in Ontario. Because the boundary line between New York State and Ontario forms an acute angle, which is intersected by the cableway about sixty feet within the apex, the promoters found themselves in a diplomatic tangle. After securing the sanction of the Province of Ontario

A Locomotive That Burns Pulverized Coal

OUR modern locomotives are voracious creatures. To fire one of them—the Twentieth Century Limited, for instance—is a task gradually approaching the superhuman. The

lignite and peat, are as productive of economic results as the larger and better grades of coal. Some of the products mentioned are unsalable and have been thrown away as waste, so the great



The Fuel Container, Which Is a Part of the Ordinary Locomotive Tender, Receives the Coal Dust or Pulverized Coal Through Two Openings in the Top. The Fire-Box Is Provided with Brick Arches and Air Inlets. A Slag Pan Is Used Instead of the Usual Ash Pan

only remedy, according to railroad men themselves, lies in the utilization of pulverized coal. Of only comparatively recent date, however, have appliances for burning powdered fuel or coal-dust in locomotive fire-boxes been effectively developed. The results have been entirely satisfactory, effecting a saving of from fifteen to twenty-five per cent of fuel and untold labor.

This economy is possible because any solid fuel which in a dry, pulverized state has two thirds of its content combustible will be suitable for steam-generating purposes. This means that such ordinary coal products as dust, sweepings, culm, screenings and slack, and even

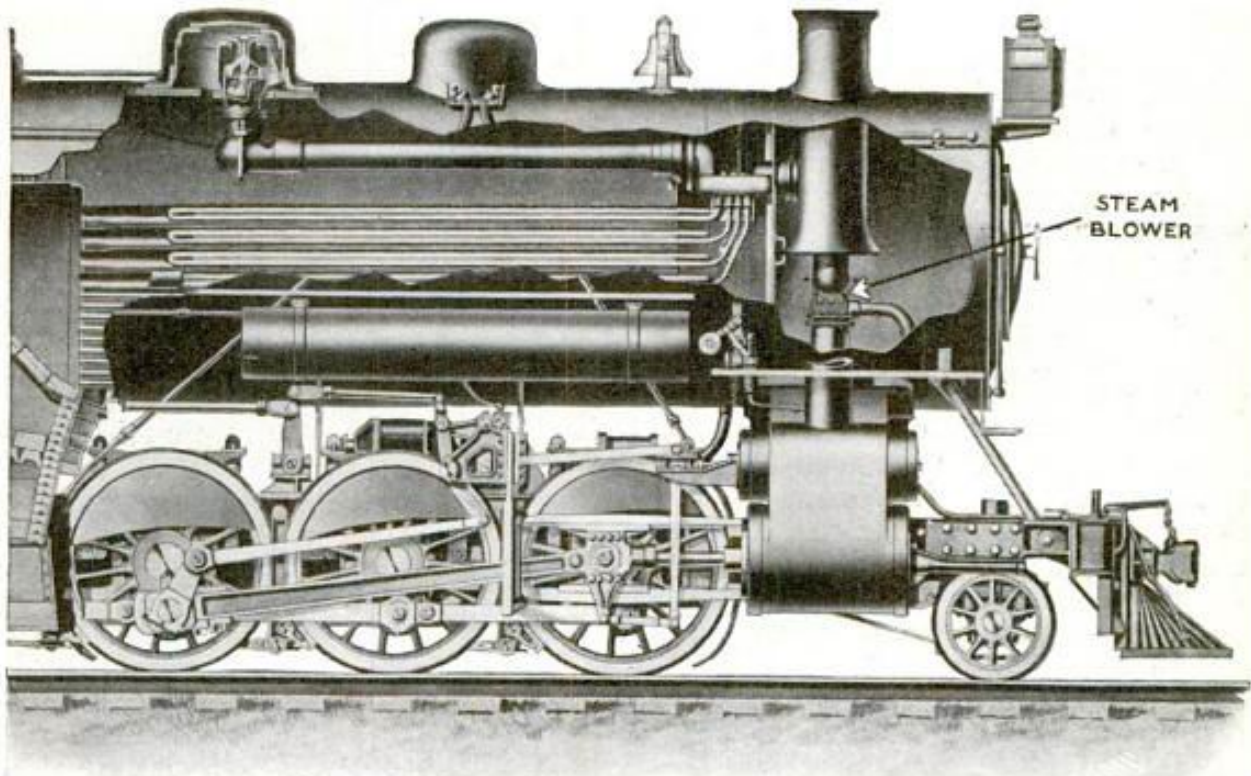
saving effected is apparent. The total cost to prepare pulverized coal is something less than twenty-five cents a ton, and the preparation is not at all complicated. The coal must be dry and ground to a fineness so that it will pass through a one-hundred or two-hundred mesh screen. This is all the preparation necessary.

There are three railroad lines which have locomotives fitted with a successful apparatus to burn coal-dust. These are the New York Central, the Chicago and Northwestern and the Delaware and Hudson. The last-named system has probably the largest pulverized fuel-burning locomotive. Its tractive effort is about sixty-three thousand pounds.

In the accompanying illustration is shown the pulverized fuel-burning equipment as applied to a locomotive. The fuel container, which is a part of the ordinary locomotive tender, receives the coal-dust or pulverized coal through two openings in the top. As dryness of the fuel is a prime requisite these openings are kept tightly closed. In starting the fire the fireman turns on the steam-blower in the smoke-box, after which he

his place in the cab near the engineer.

When the powdered coal and air are mixed in the right proportions, the mixture bursts into a clear, intense flame in the fire-box, with no visible smoke at the stack. It takes less than an hour to get up two hundred pounds of steam, and when the engine is standing the fire may be put out entirely and then reignited within an hour from the heat of the brick arches in the fire-box.



In Starting the Fire the Fireman Turns on the Steam-Blower in the Smoke-Box. The Air-Blower Motor and the Fuel-Conveyor Motor Are Then Started and Fuel and Air Enter the Combustion Furnace Which Is an Ordinary Locomotive Fire-Box with a Fire-Brick Floor

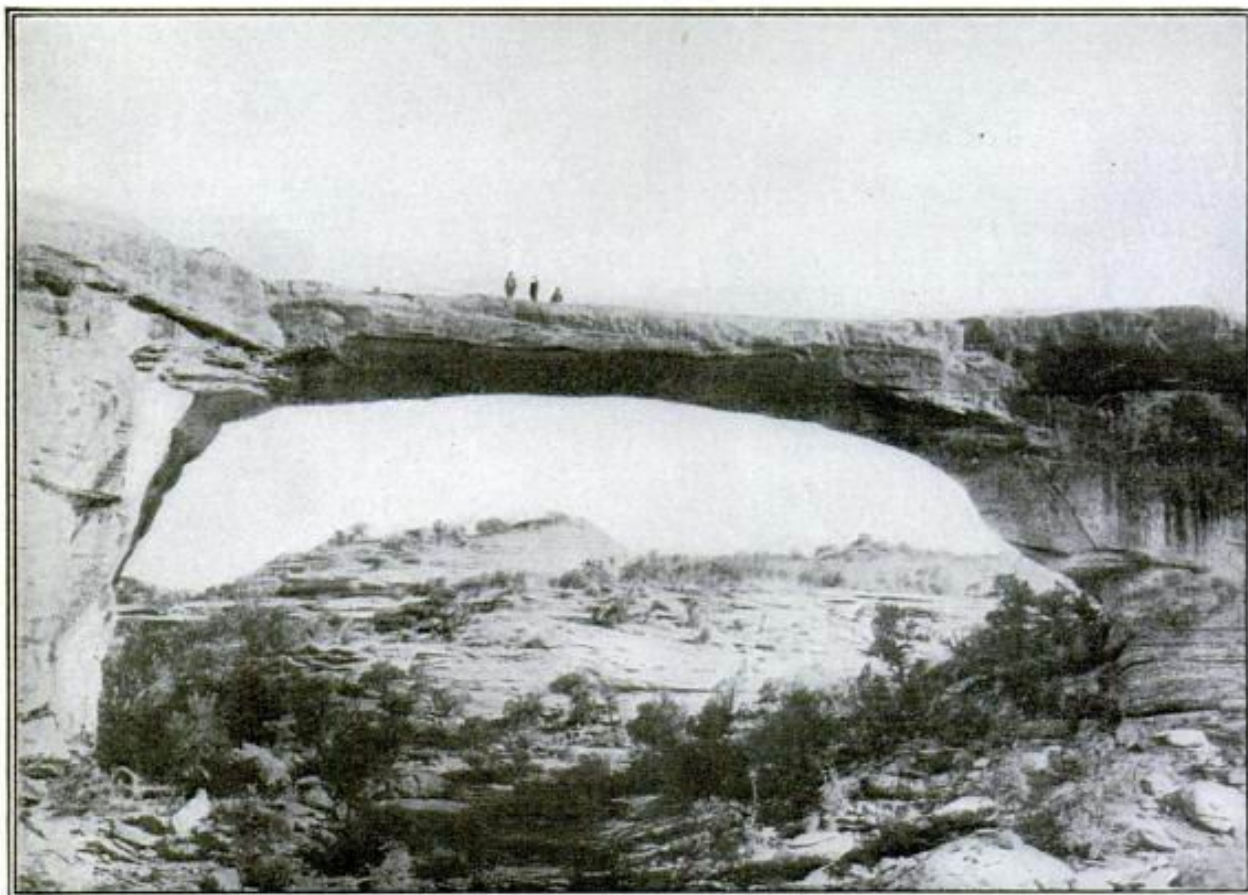
places a piece of lighted oil-waste in the furnace. Immediately following this he starts the air-blower motor and the fuel-conveyor motor. The screw-conveyor forces the fuel into the fuel feeder, where it meets the air driven by the blower. The fuel and air are then driven through a commingler, and this mixture then enters the combustion furnace, which is the ordinary locomotive fire-box fitted with a fire-brick floor in place of grate bars, where the lighted oil-waste ignites it. The fire-box is provided with brick arches and air inlets. There is a slag pan instead of the usual ash pan.

The regulating mechanism controlling air and fuel is within reach of the fireman, so he need never have occasion to leave

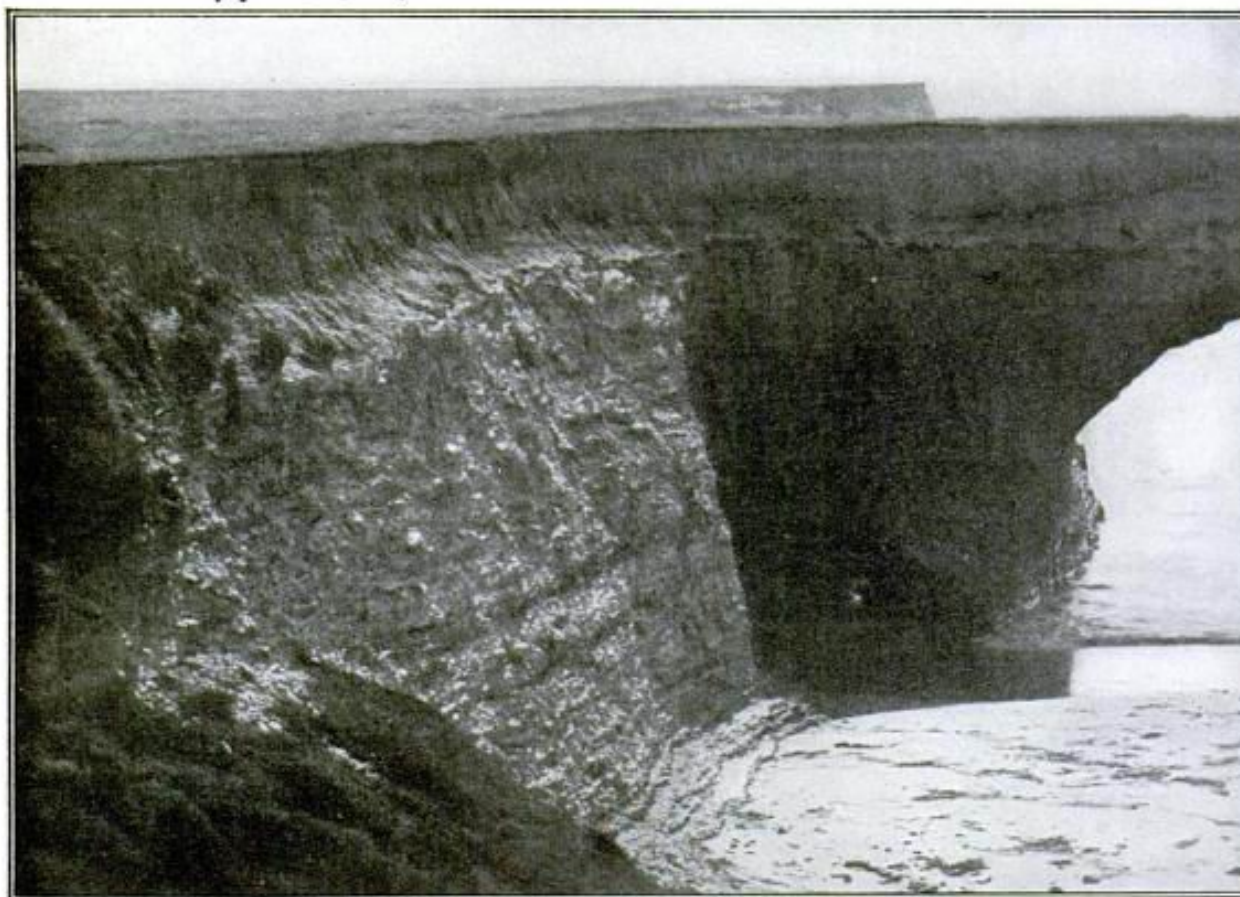
The Wastage of Flying Machines In the Great War

THE English aeronautic periodicals publish fairly complete lists of casualties sustained by the flying squadrons of the Allies as well as by those of the Germans. In a single month on the western front, the British brought down sixteen German aeroplanes, the French thirty. The British losses, on the other hand, were ten, and the French twenty-eight. If machines are shot down with such ease on both sides, the wastage of aeroplanes in this war must be enormous. No wonder that thousands of men are employed in the aeroplane factories of all the warring countries to make up the losses.

When Nature Plays the Architect of Bridges



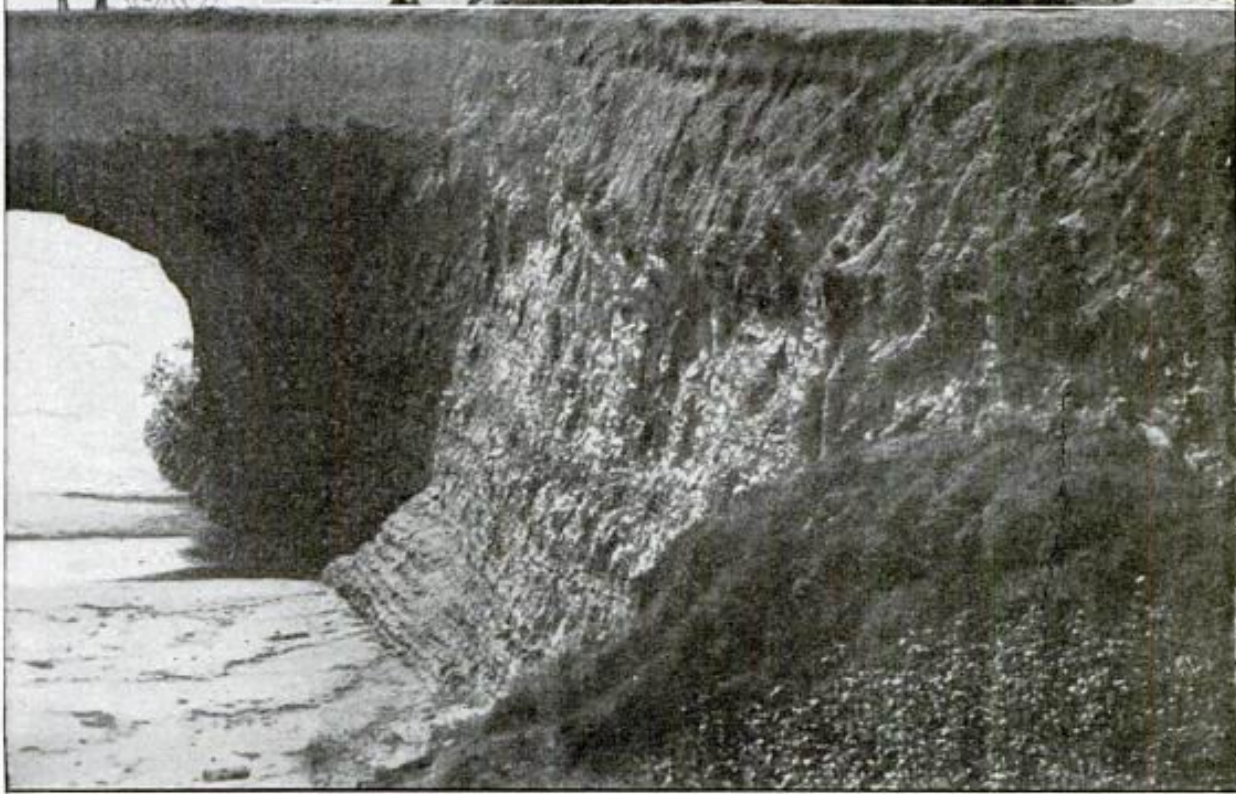
The Nonnezoshe, or Rainbow arch, shown above, has been carved by the elements from the brick-red sandstone of southeastern Utah. The Navajo Indians called it the Sun-Path and beneath it are ruins of an ancient altar doubtless built by superstitious cliff-dwellers

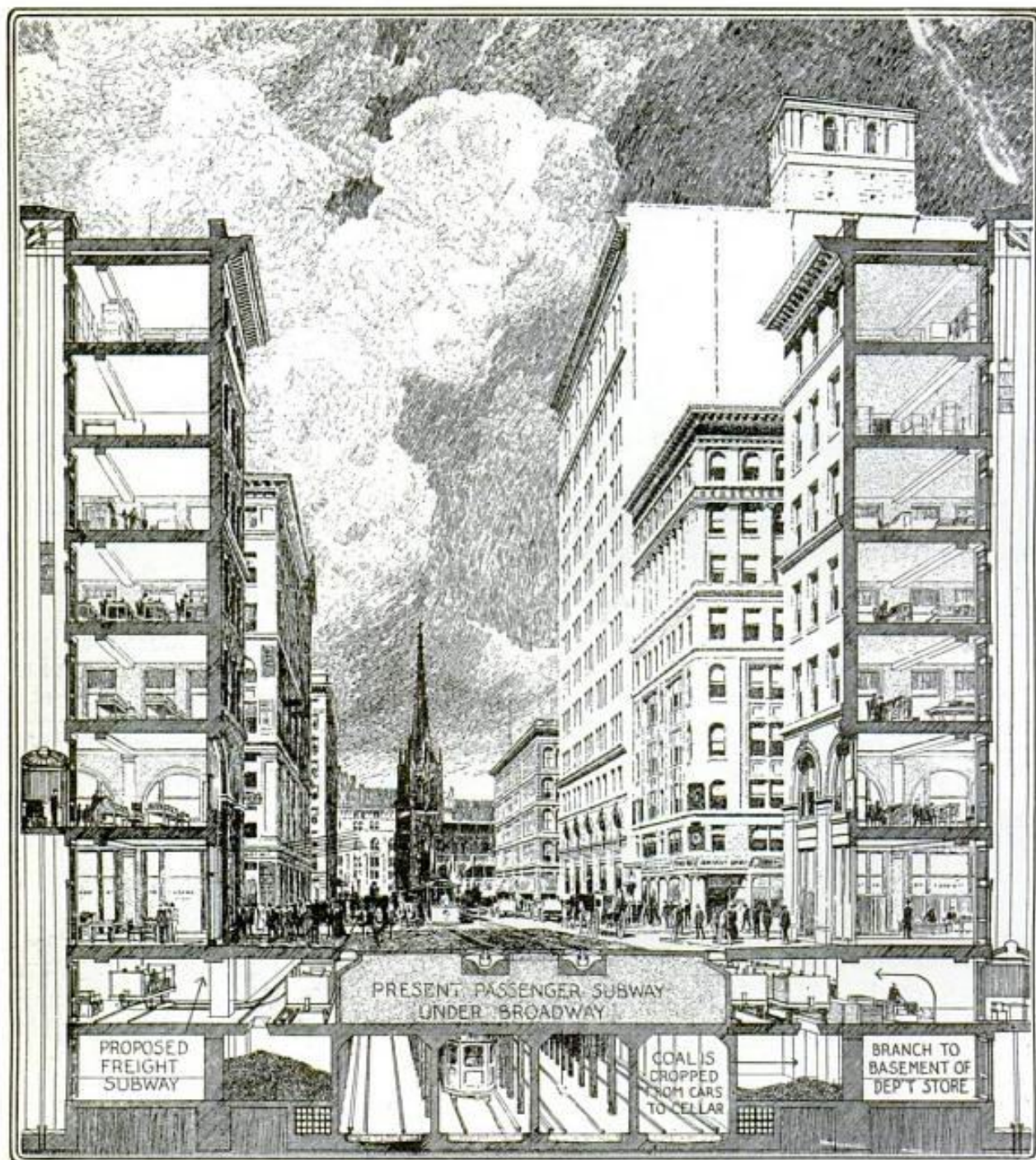


Her Tools Are the Elements and World-Old Rock

Notwithstanding the fact that the Owachomo Bridge in southwestern Utah, shown on the right, is called the "Little Bridge," it is one hundred and six feet high and nearly two hundred feet wide

The natural bridge of Santa Cruz, California, shown in the picture extending across both pages below, arches a perfect causeway, which has been formed by the inrush and outwash of waves during many centuries





New York city wastes millions in cartage. If the Wilgus plan is adopted, a freight subway will run through New York city, paralleling the present passenger subway in some sections, for the purpose of transporting the freight underground and through tunnels under the Hudson River to its destination, thus saving the additional expense of re-transference

of the congestion at that point. It has been stated that it cost more to haul a ton of freight from a railroad terminal in Jersey City to a warehouse in Manhattan than from Pittsburg to the seaboard. R. A. C. Smith, Commissioner of Docks and Ferries, has suggested that the time required to load the trucks might be reduced by constructing pier-sheds in such a way as to permit the trucks to go out upon

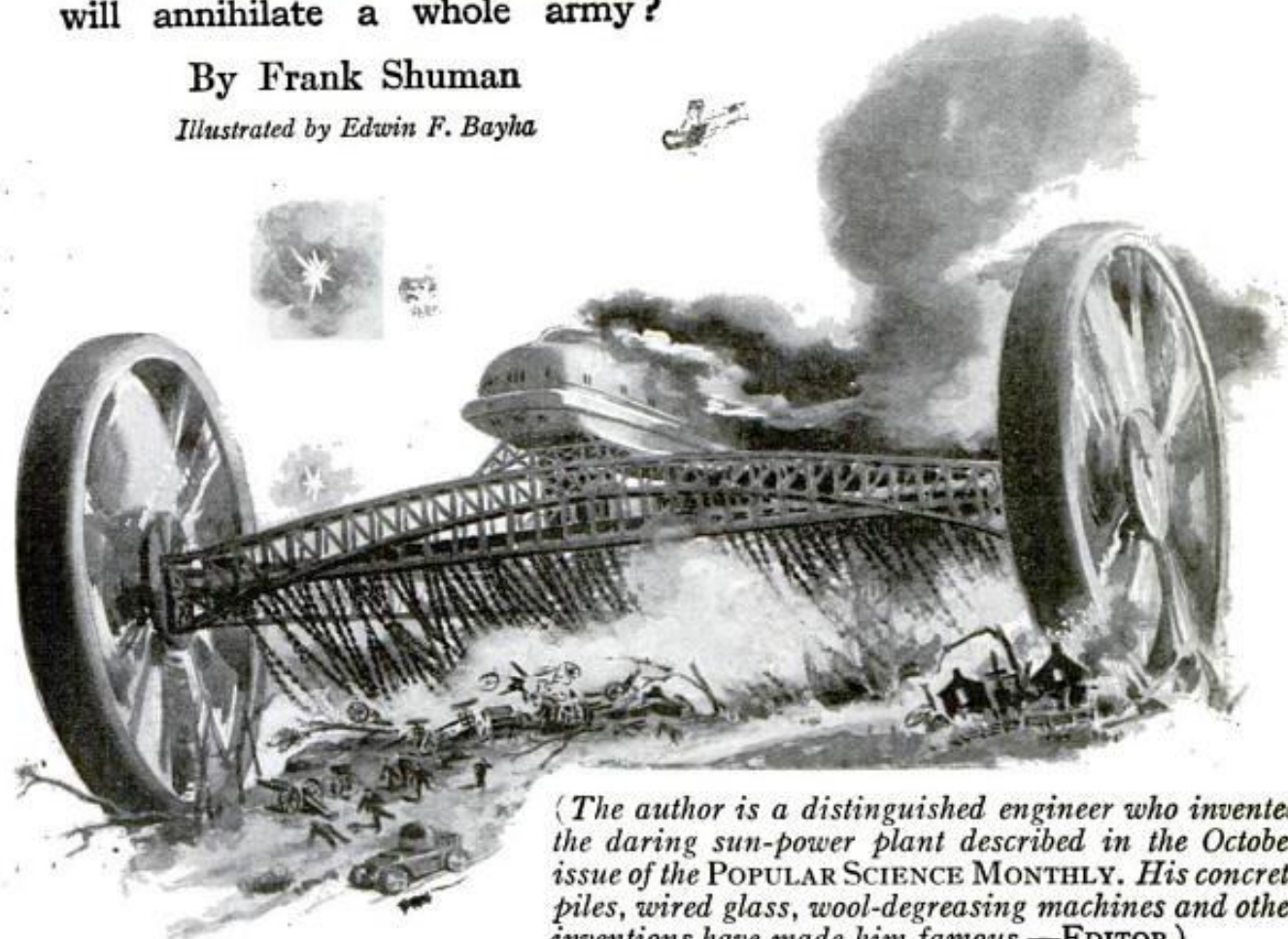
them at one side, enter in order through a series of doors, and return in a regulated procession. William J. Wilgus, a former vice-president of the New York Central Railroad, has submitted to the public Service Commission a project for transshipping freight to smaller cars at a great terminal yard to be established on the Hackensack Meadows. These cars were to be operated by electricity through tunnels under the Hudson River

The Giant Destroyer of the Future

Can a juggernaut be built which
will annihilate a whole army?

By Frank Shuman

Illustrated by Edwin F. Bayha



(The author is a distinguished engineer who invented the daring sun-power plant described in the October issue of the POPULAR SCIENCE MONTHLY. His concrete piles, wired glass, wool-degreasing machines and other inventions have made him famous.—EDITOR.)

A CLUB, a bow and arrow, a blunderbuss, an infantryman's rifle, a forty-two centimeter howitzer are merely instruments for delivering blows. The essential difference between the battles of prehistoric times and those of today lies in the manner of delivering blows. Smokeless powder has merely lengthened the arm of a modern fighter. He strikes and kills at a distance of miles.

For all our machine-guns, for all our terrible "artillery preparation," battles are still won by bayonets. Tactics have been somewhat modified since Napoleon's day, because of the invention of the machine-gun and the high-powered field-piece. But the individual fighter is still as important as he ever was. We speak of the German or French or Russian "war machine," when we mean a million or more individuals trained to act with a precision that roughly approximates that of a modern university football team.

Only the Battleship Is a Real War Machine

Because armies are still composed essentially of many individuals, fighting ships may be more fittingly termed "war machines." A modern battleship is a real machine. The men on board are merely so many intelligences that control the steam-engines, the turrets, the great guns, the searchlights. No one ever hears now of hand to hand conflicts at sea. Ships are sunk at ranges of five and seven miles. But land warfare is still waged not by a few machines, as on the sea, but by organized millions of men.

Armies have increased in size. Fighting ships, on the other hand, have diminished in number. Contrast the numerical strength of the British Navy now with what it was in the days of Drake and Nelson. A few dozen ships, highly intricate machines, have taken the place of hundreds.

Why is there no land battleship, something comparable with our own Penn-

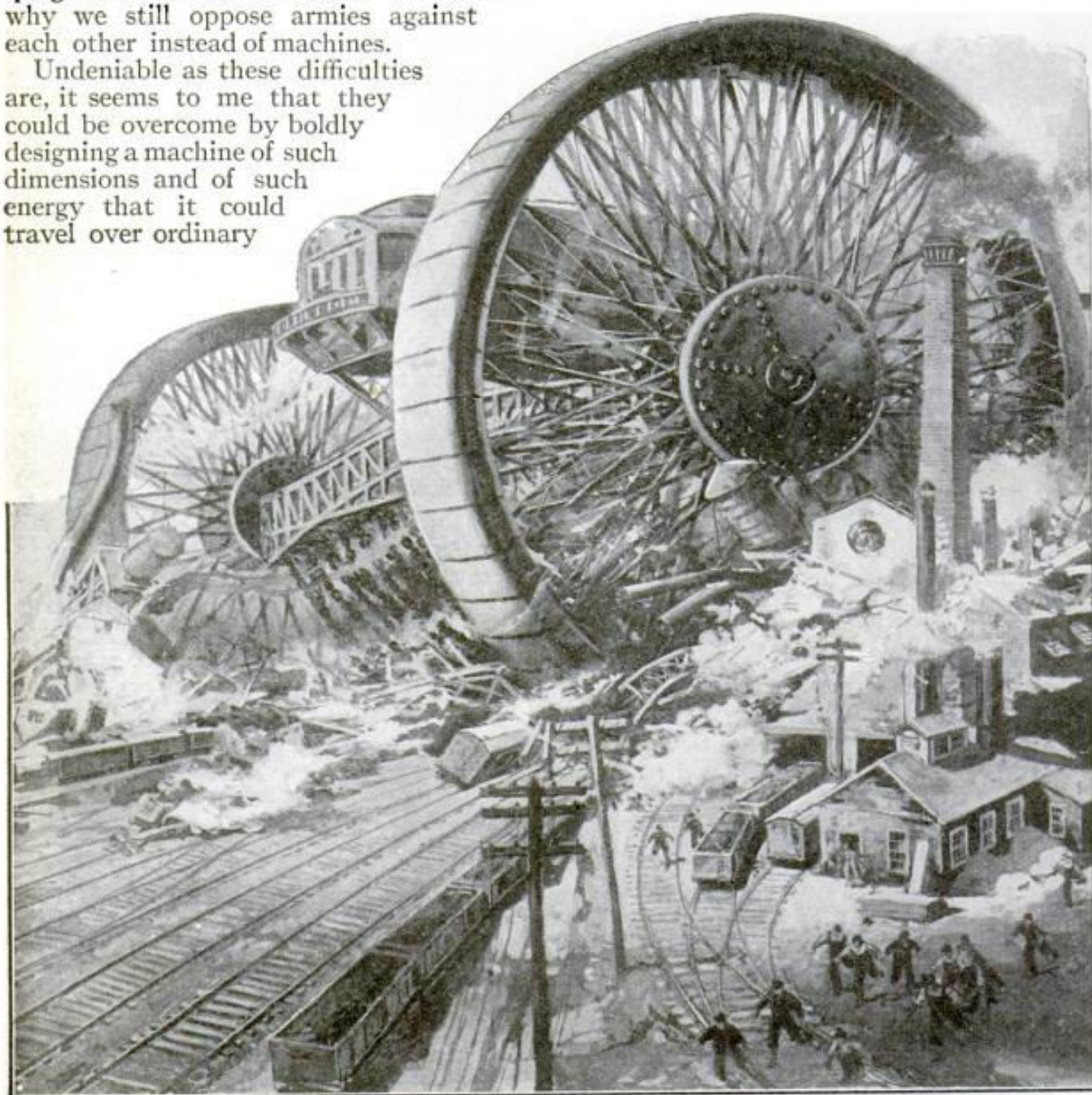
sylvania, something which will concentrate within one volume the striking power of an army?

Why Not a Battleship On Land?

There is no good engineering reason why an enormous wheeled structure, heavily armored and capable of traveling at high speed should not wage the battles of the future. Technically, it is a far easier task to design and build a super-dreadnought than a wheeled destroyer to run on solid ground. The ocean is a vast, level expanse. There are no hills and valleys. Water is the same in density everywhere. But land varies from the hardest rock to the softest quagmire. Here we have the reason why we still oppose armies against each other instead of machines.

Undeniable as these difficulties are, it seems to me that they could be overcome by boldly designing a machine of such dimensions and of such energy that it could travel over ordinary

land much as an automobile travels over a country road. A hill fifty feet high would be to that machine what a six-inch ridge of clay would be to an automobile; a swamp would no more hinder its course than half a foot of mud would stop a touring car. Its speed would be at least one hundred miles an hour on the long, level, sandy beaches along our coasts. And even over rough inland country it would rush far more swiftly than any touring car on a poor road. Indeed, in its speed would lie its destructive possibilities. The impact of a heavy mass moving with the velocity of an express train would be irresistible. It could mow down everything before it with the relent-



The machine proposed by Mr. Shuman would be irresistible. With its front wheels measuring 200 feet in diameter, and the weights aggregating many tons dangling down in front from chains,

lessness of a steam-roller. Guns would not be required to rout an enemy. An army would be as helpless in offering resistance as a flock of geese in the path of an automobile.

A Giant Three-Wheeled Armored Car

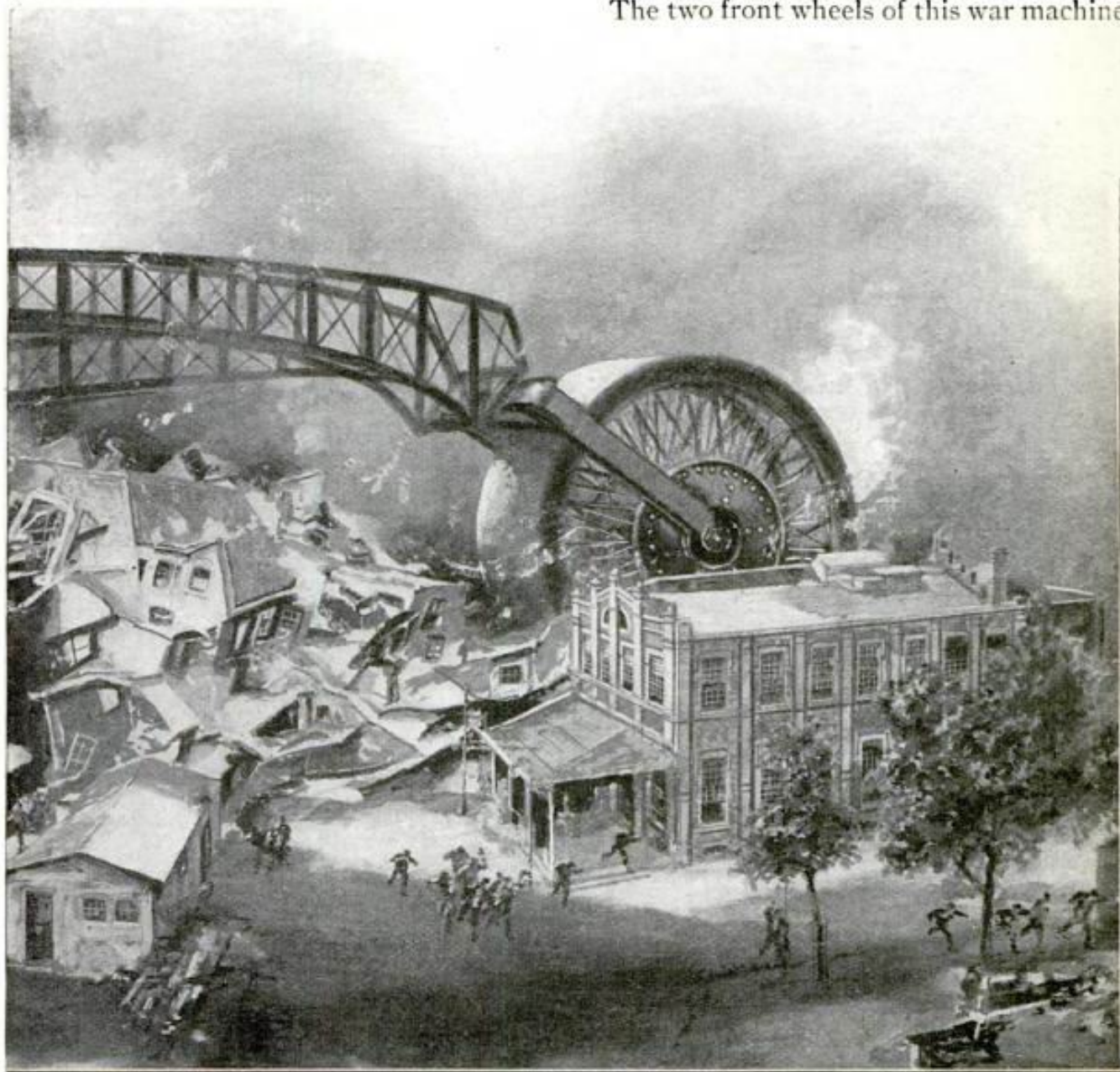
It is impossible within the limits of a short article to describe this machine which I have conceived in all its details. Picture to yourself, however, a self-propelled machine, comprising three wheels and a heavily armored body or car. There are two wheels, one hundred and fifty to two hundred feet in diameter in front, and a single smaller steering-wheel in the rear. The entire structure is short, so

that the turning radius will be small.

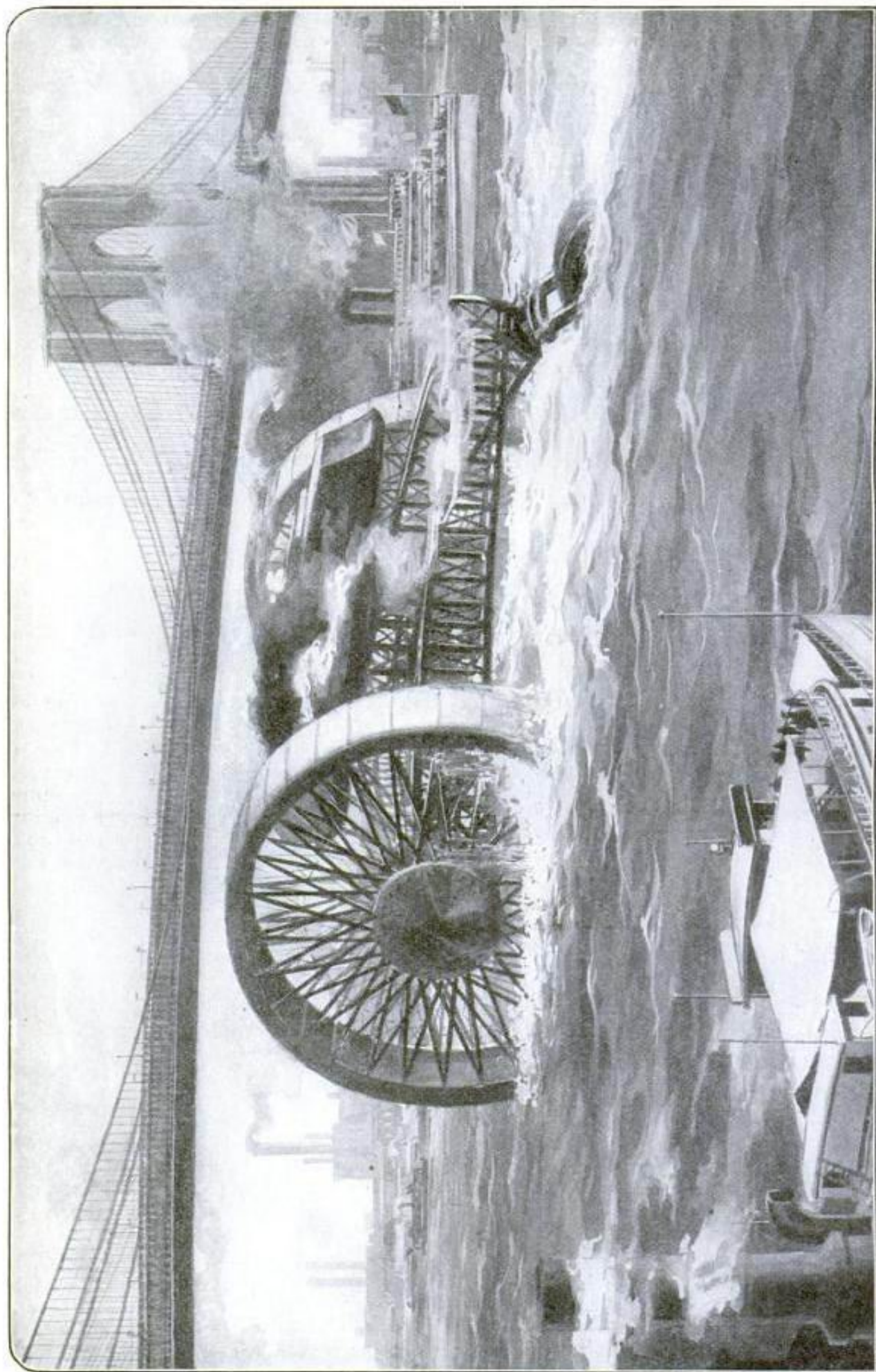
No doubt you are familiar with the military masts of our American battleships. They are latticed towers, not unlike cages. They are thus constructed so that whole sections of the lattice work may be shot away; but the remaining portions will still support the mast.

So I would build the wheels of my war machine. Why not armor them instead? They would weigh far too much—thousands of tons in fact. But the hub I would armor—and heavily. There the spokes would be concentrated so thickly that they might be shot away in great numbers. Besides, the hub and axle must be well protected. Therefore the center of each wheel would be a mass of armor as thick as that of a battle cruiser.

The two front wheels of this war machine

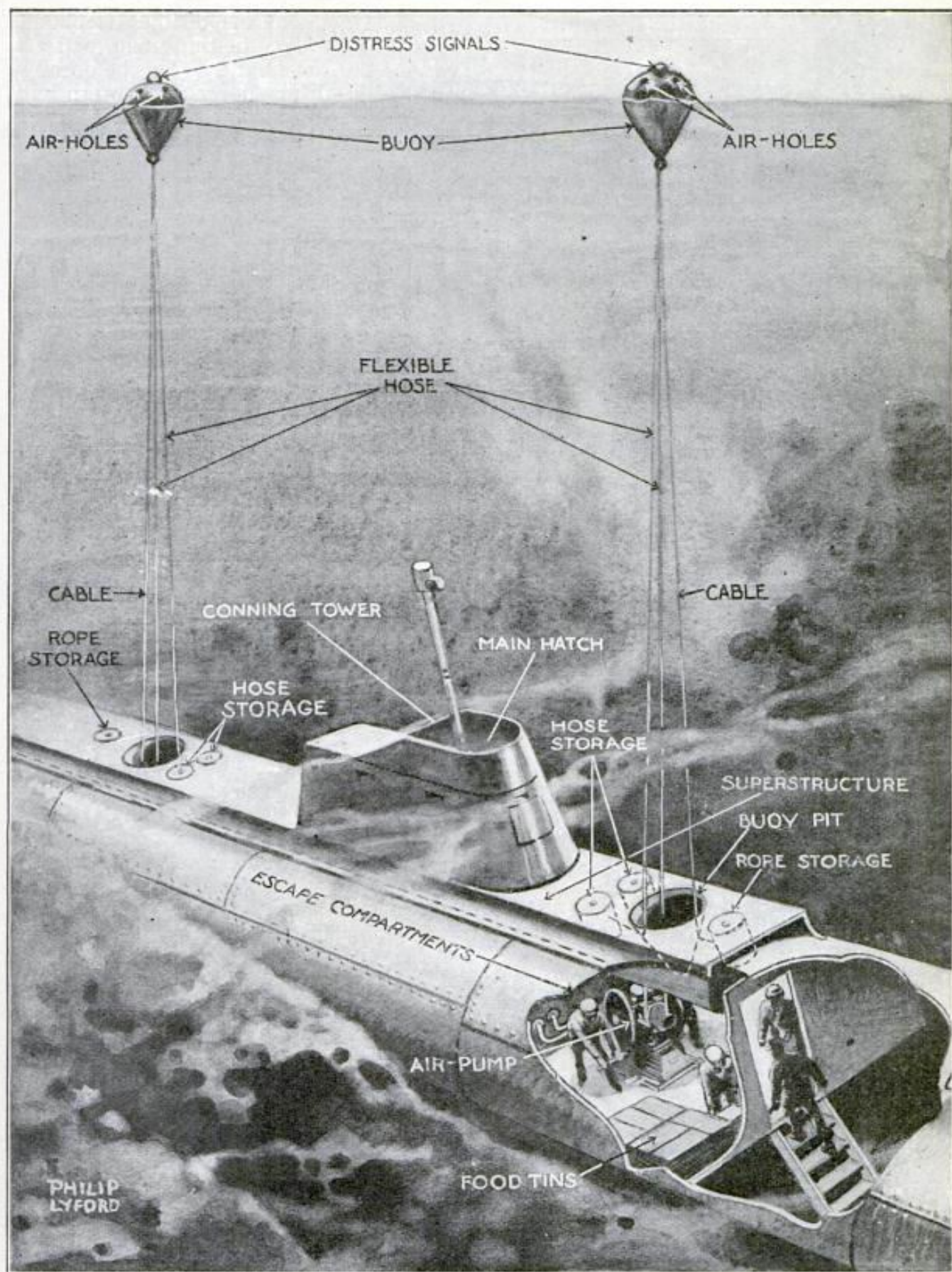


it would plow through a whole town, blotting it out of existence as if it were a mere ant-heap. The wheels would be latticed, so that shot might pass through without destroying them



Ordinary rivers and marshes would not stop the machine. Few rivers are more than fifty feet deep. The 200-foot wheels of the machine would dash through them as easily as an automobile through a pool of mud

Signaling for Help with Flashlight Buoys



The crew get into the compartments and release the buoys. Until their distress signals are answered, they receive a supply of fresh air through the hose attached to the buoys. On the arrival of a salvaging ship, the submarine is hauled up by means of the cables and the men are freed

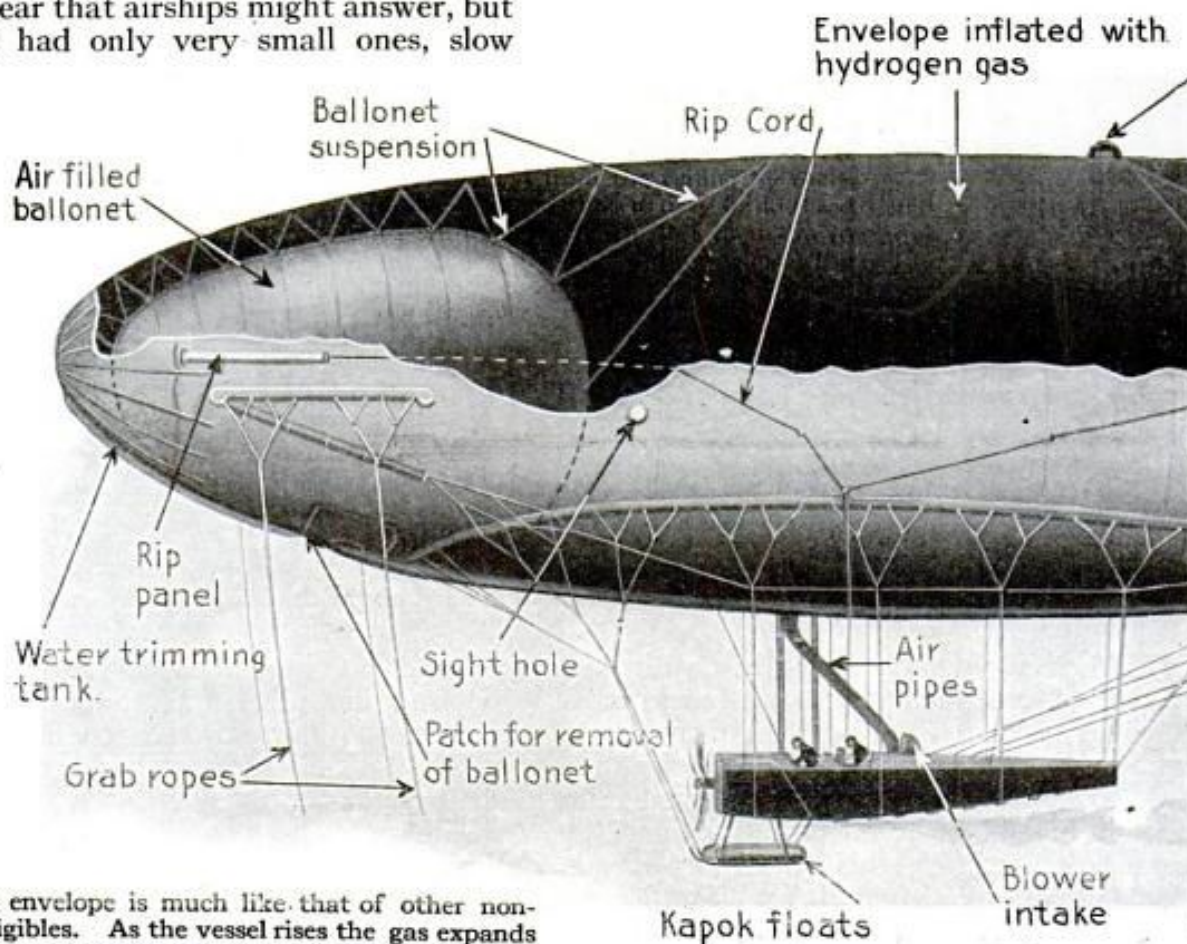
Our First Scouting Dirigibles

We have copied the British "Blimps."
Here the construction is explained

WHEN German submarines began to render even the high seas dangerous to shipping, England found herself in a very perilous position. To patrol the waters around England by small craft was the immediate remedy adopted. But the area to be covered was so vast that literally thousands of vessels would have been required. Airplanes were out of the question because they lacked the necessary endurance and because of the demands made on the pilot. It was clear that airships might answer, but England had only very small ones, slow

flying and very unhandy for the purpose.

Some unknown genius hit upon the "Blimp" as a solution of the problem. England was building airplane bodies, or fuselages, as they are called, by the thousands—building them as we build automobiles in this country. She was also producing hundreds of gas envelopes. Why not suspend an airplane fuselage from a gasbag? The question was brilliantly answered by the "Blimp."



The gas envelope is much like that of other non-rigid dirigibles. As the vessel rises the gas expands and some of it escapes through a safety valve to prevent bursting. To preserve the shape when the gas contracts, ballonets are used, one in front and one in the rear, as explained on next page

The Forty-Five-Mile-An-Hour "Blimp" Which Was Considered a Makeshift in the

The gasbag is 160 feet long and 31½ feet in diameter, with a capacity of 77,000 cubic feet of gas. There is a standard 100-HP motor provided with duplicate controls so that the two passengers can run the ship alternately. Wheels are not needed under the car or

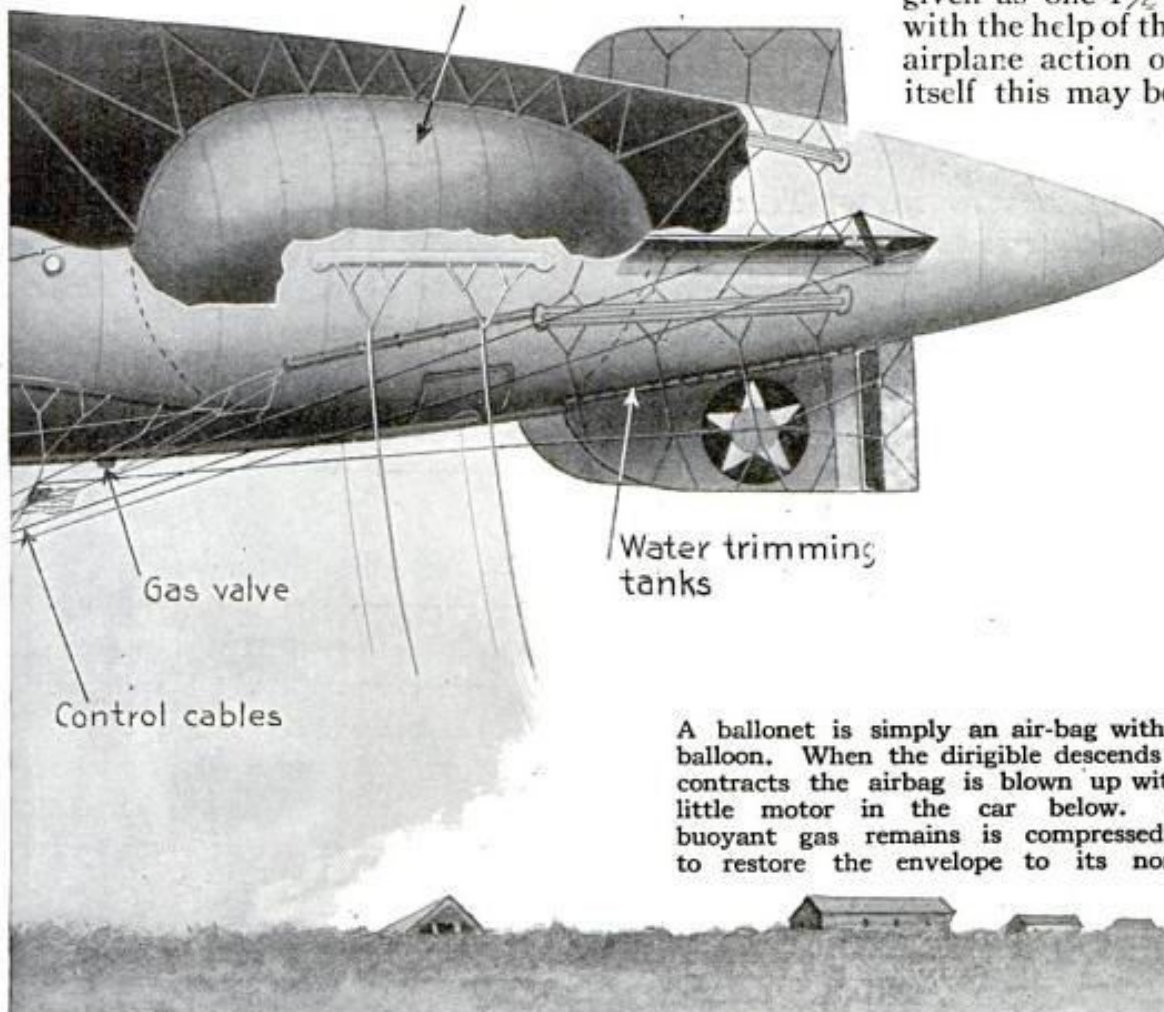
fuselage. Even with more load than the gas can lift the vessel can be made to rise easily without a preliminary run on the ground, simply by pointing the nose up (through air trimming) and letting the propeller exert an upward thrust. The chief difficulty with all

So little trouble was taken to adapt the airplane fuselage to the gas envelope that not even a motor-driven blower was provided for the airbag in the first Blimps. Part of the airplane propeller's slipstream, caught in a hose, sufficed.

The hybrid "Blimp" has shown itself incredibly superior to anything in its own class. It has a speed of forty-five miles an hour and a radius of action of several hundred miles. Its lift control approaches the seventy-mile-an-hour Zeppelin's, because the "Blimp's" surface is relatively greater, compared with its weight, than a Zeppelin's. Moreover, for the same speed the dirigible with a greater relative surface has more grip on the air in rising or descending by reason of the airplane effect of its gasbag than if it had a surface smaller in proportion to its weight.

Pressure relief valve

Ballonet



Gas valve

Control cables

Water trimming tanks

A ballonet is simply an air-bag within the main balloon. When the dirigible descends and the gas contracts the airbag is blown up with air by a little motor in the car below. Thus what buoyant gas remains is compressed and made to restore the envelope to its normal shape

Beginning Has Proved a Brilliant Invention And a Real Innovation in Dirigibles

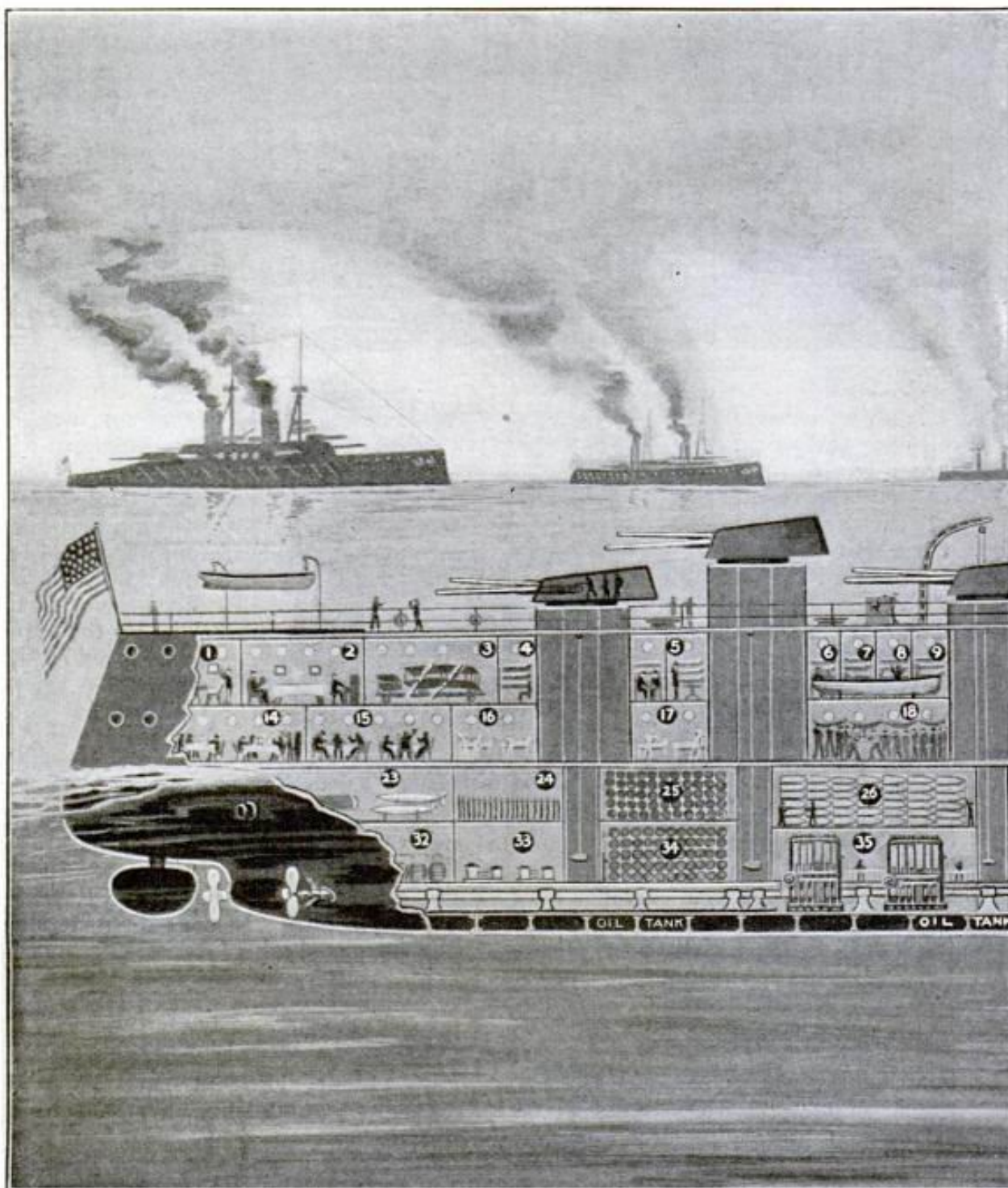
dirigibles is the erratic changing of the lifting force of the hydrogen gas with which they are inflated. Whenever the sun disappears, the gas cools and shrinks. When the vessel enters a cold stratum of air the gas shrinks, to expand again upon reaching a warmer

The United States has also built "Blimps." The main original features of the American "Blimps" is the addition of a blower driven by a cycle-motor and of a second airbag or ballonet with valves to shift the air at will from bag to bag.

As a result, the ship can be "trimmed" (that is, its flotation forward and aft can be varied at will by driving the gas where there is less air) even while it is at rest and the elevator or vertical rudder is powerless. The blast of the propeller will probably be used to inflate the ballonets, that being safer than a separate motor. There has been added an efficient device for anchoring the vessel safely in a storm. The equivalent of life belts, in the form of kapok buoys are fastened above the airplane's floats. Hence the entire craft can rest lightly on the water, supported by its gas. Enough water and sand ballast are carried to permit the craft to rise the better part of a mile; the safe altitude is given as one $1\frac{1}{2}$ miles, but with the help of the powerful airplane action of the craft itself this may be doubled.

layer. But even the old slow dirigibles could add or subtract much weight to or from their lift by reason of their airplane action. As this action increases proportionately with the square of the speed the fast dirigible of today compensates easily for such variations

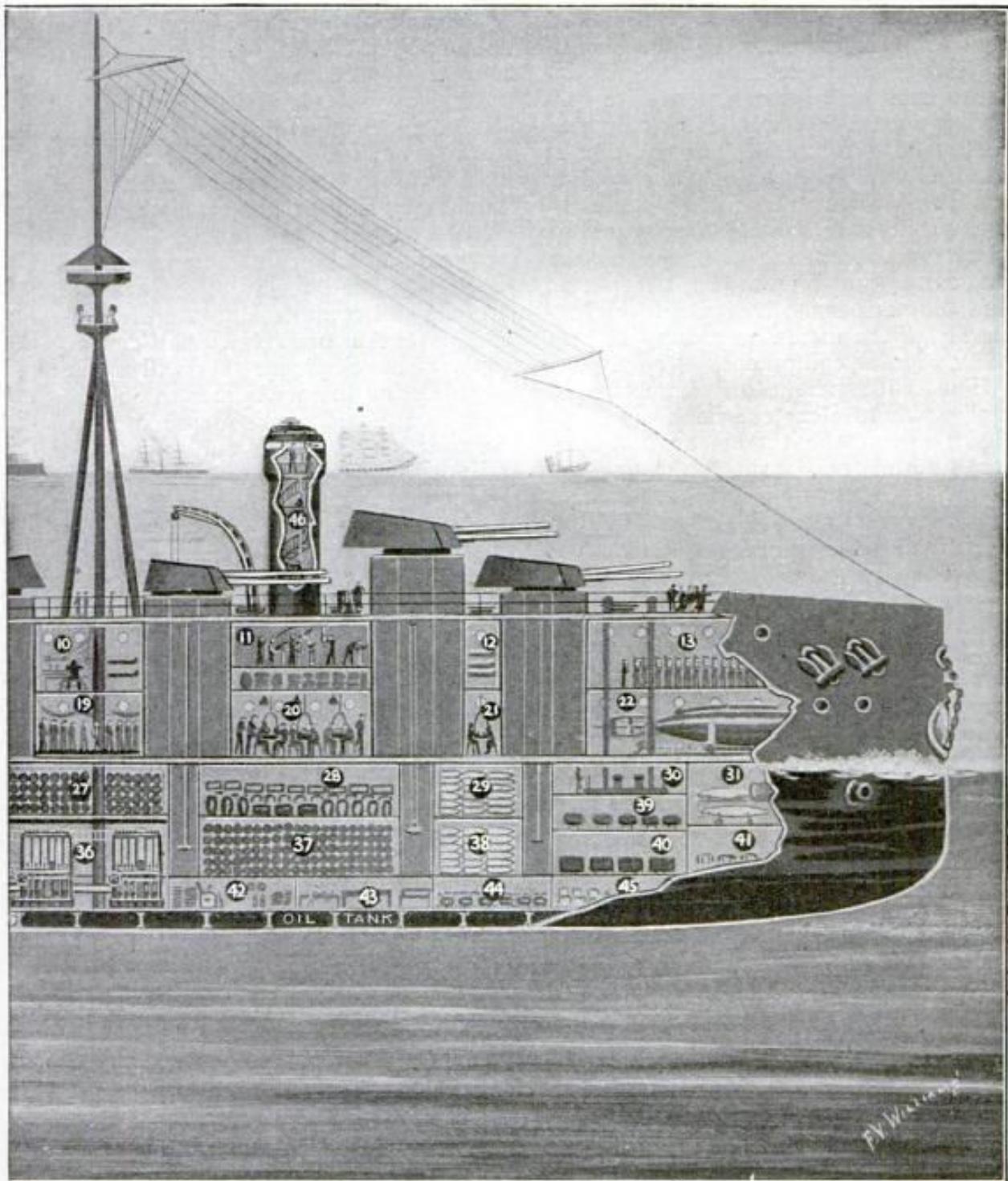
MOTOR-DRIVEN BATTLESHIP OF THE FUTURE



1 and 2—Admiral's Quarters
 3—Aeroplanes
 4-9—Warrant Officers' Quarters and Lifeboats
 10—Wireless Operator's Room
 11—Chart Room
 12—Petty Officers' Quarters
 13—Drill Deck
 14 and 15—Officers' Quarters and Ward Room

16 and 17—Hospital
 18-21—Crew's Quarters
 22—Submarine
 23—Stern Torpedo Room
 24—Armory
 25-27—Ammunition
 28—Provisions

AND ITS LONG LINE OF PREDECESSORS

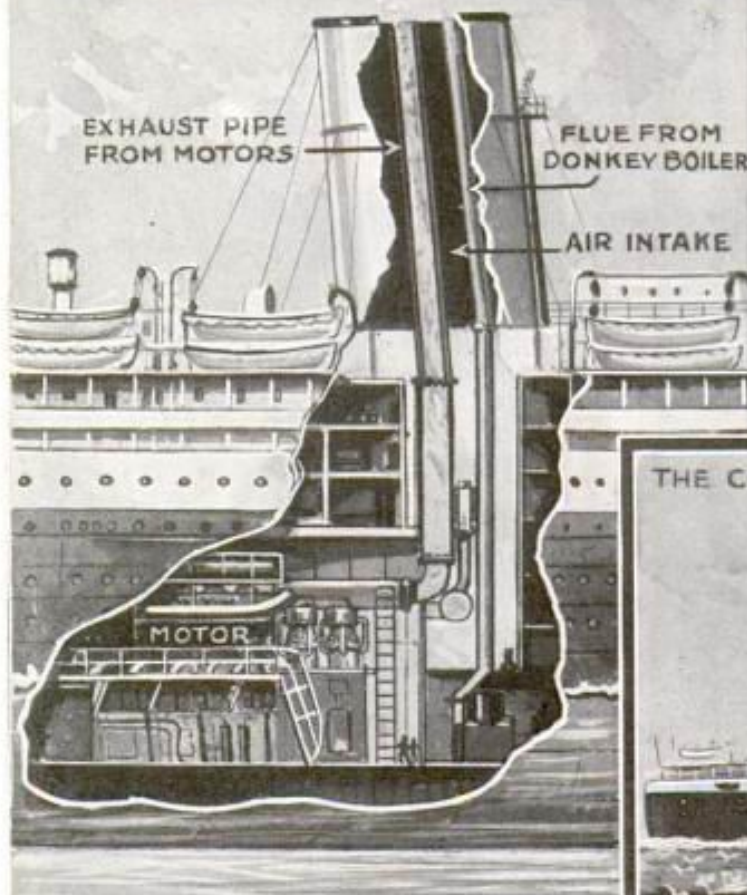


29—Ammunition
 30—Dynamos
 31—Forward Torpedo Room
 32—Storeroom
 33—Dynamos
 34—Ammunition
 35 and 36—Gas Engines

37 and 38—Ammunition
 39 and 40—Mines
 41—Torpedo Stores
 42—Boatswain's Stores
 43—Carpenter
 44 and 45—Provisions
 46—Conning Tower

Dummy Funnels in Motorized Liners

WHAT IS INSIDE THE FUNNEL OF A MOTOR LINER.



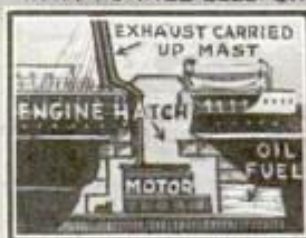
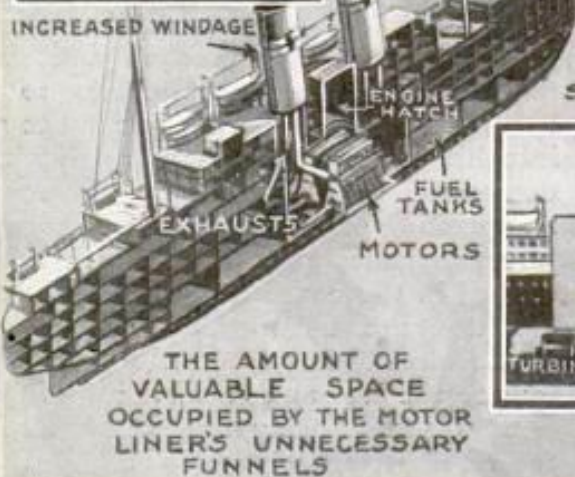
THE "CITY OF ROME" OF 1881 WITH POWERFUL AND RELIABLE STEAM ENGINES, YET ABLE TO CARRY A LARGE SPREAD OF CANVAS TO SATISFY THE OCEAN VOYAGERS OF THOSE DAYS



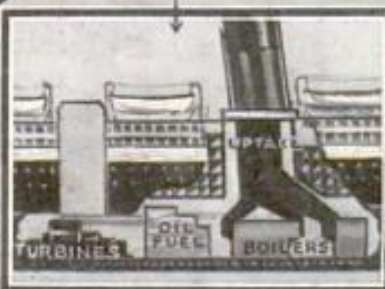
THE COMPROMISE—THE REDUCED HEIGHT OF



SPACE OCCUPIED BY MACHINERY IN A FUNNEL-LESS SHIP

INCREASED HEAD RESISTANCE
OWNER'S FUNNEL MARKINGS RETAINED

SPACE OCCUPIED BY MACHINERY IN THE STEAM-DRIVEN LINER



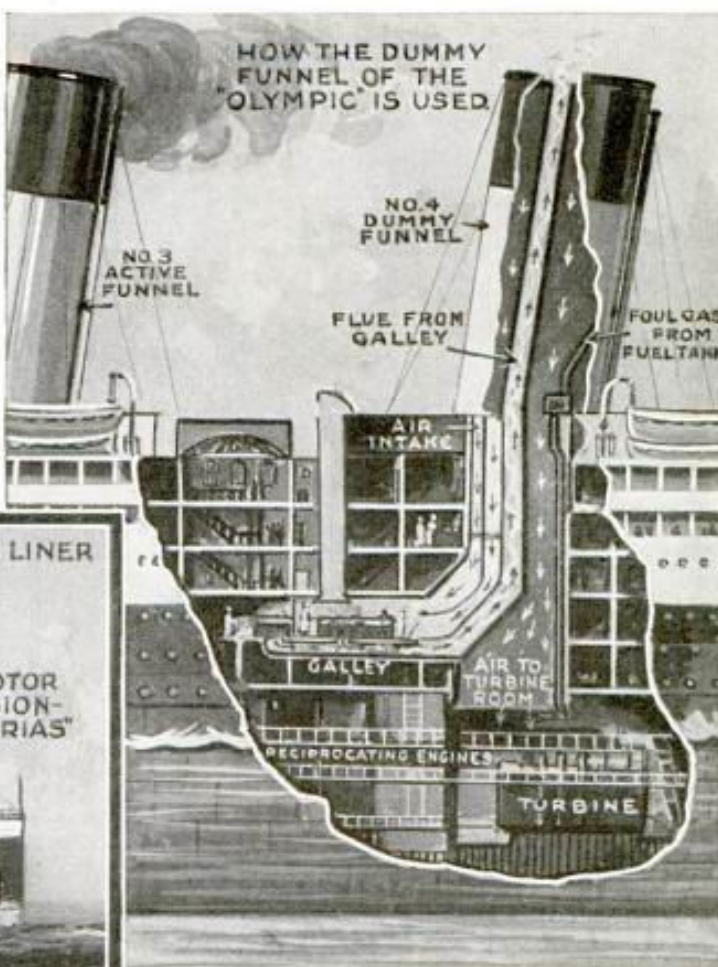
MOTOR SHIPS BUILDING AT THE END OF 1925—GROSS TONNAGE 994,186

Constructors, Forced to Provide Smokestacks for Smokeless Ships, Convert Them into Air Ducts, Covering for Exhaust Pipes, and Use the Base Space as Storerooms for Supplies

to Satisfy the Ocean-Going Public



THE COMING OF POLE MASTS, HUGE FUNNELS AND TWIN SCREWS. THE "CAMPANIA" OF 1892



HOW THE DUMMY FUNNEL OF THE "OLYMPIC" IS USED

NO. 3 ACTIVE FUNNEL
NO. 4 DUMMY FUNNEL
FLUE FROM GALLEY
FOUL GAS FROM FUEL TANK
AIR INTAKE
GALLEY
AIR TO TURBINE ROOM
RECIPROCATING ENGINES
TURBINE



THE FUNNELS OF THE LATEST MOTOR LINER

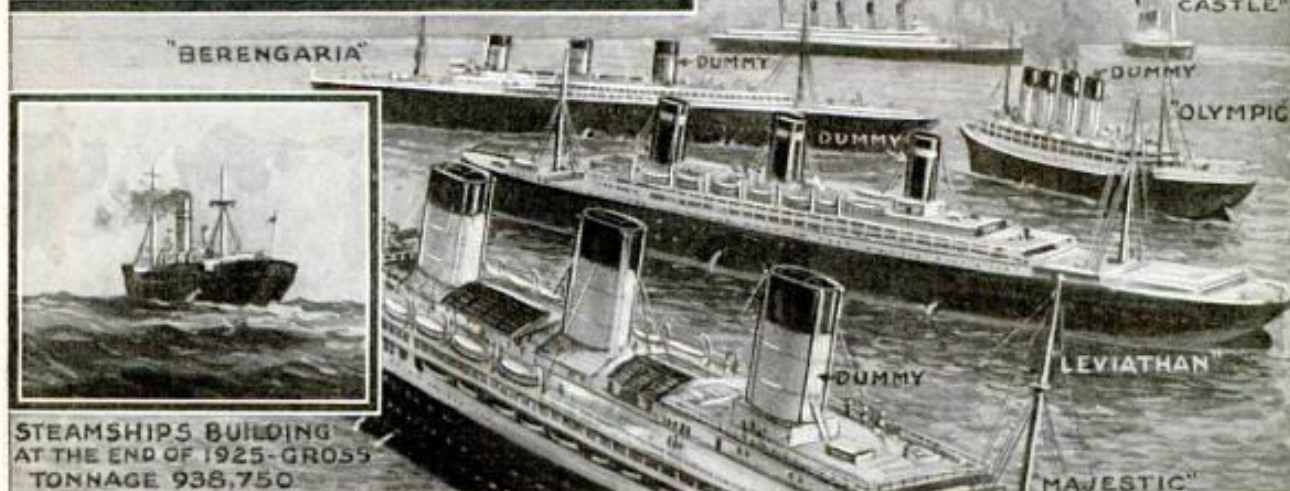
DUMMY FUNNEL

THE LARGEST MOTOR SHIP IN COMMISSION - THE LINER "ASTURIAS" - 22,137 TONS.

THE "DANMARK," LARGEST MOTOR SHIP OF THE WORLD WITHOUT A FUNNEL, 12,400 TONS

NOW REACHED A TONNAGE IN EXCESS OF 22,000; WITHOUT FUNNELS ON THE PART OF PASSENGERS, PROPORTIONS AND CHIEFLY USED FOR CARGO CARRYING

THE SHIP WITH THE NUMEROUS FUNNELS (A CRAZE THAT HAS PASSED)



"BERENGARIA"

DUMMY

"WINDSOR CASTLE"

DUMMY

"ARUNDEL CASTLE"

DUMMY

"OLYMPIC"

DUMMY

"LEVIATHAN"

"MAJESTIC"



STEAMSHIPS BUILDING AT THE END OF 1925 - GROSS TONNAGE 938,750

Plan of the proposed "artificial spa" that will give city dwellers the opportunity to enjoy the advantages of all climates and health resorts with little trouble or expense. In the central area, visitors can swim or bask in artificial sunlight on a beach of sterilized sand, while booths surrounding the main hall offer medicinal baths, mineral waters, and various therapeutic treatments

Drawing by
B. G. SEIELSTAD

MOVIE
THEATER

GYMNASIUM

HEALTH BATHS OF EVERY KIND
INCLUDE SPECIAL WATERS, VAPOR,
HOT AIR, LIGHT, AND ELECTRICITY

AIR CONDITIONERS
MAINTAIN ARTIFICIAL
CLIMATE

ENTRANCE
LOBBY

GLASS DOME
ADMITS DAYLIGHT

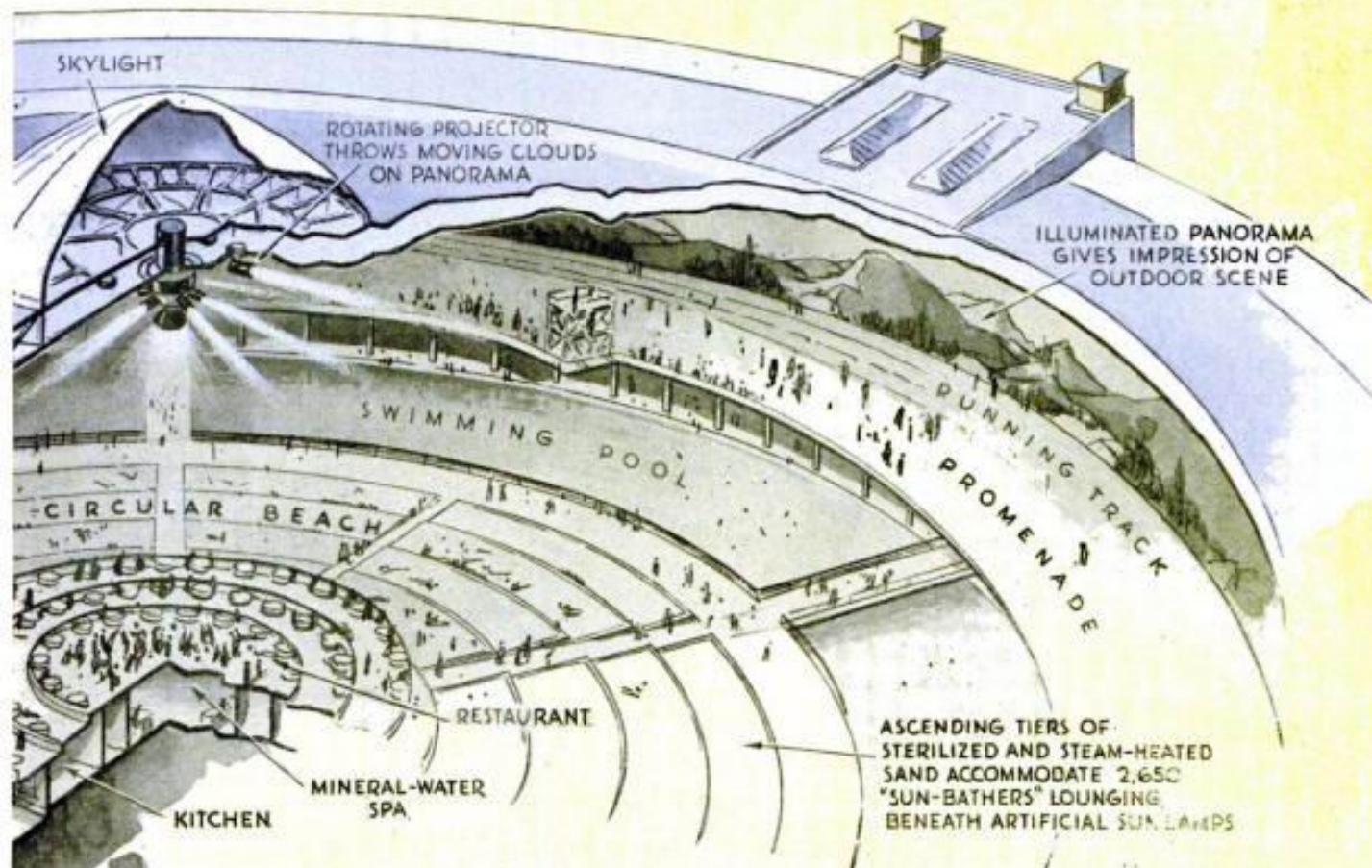
ARC LAMPS
SUPPLEMENT
ILLUMINATION
OF SAND BEACHES
AT NIGHT

TWO CIRCULAR ROWS OF
ULTRA-VIOLET LAMPS
PROVIDE ARTIFICIAL
SUNLIGHT DAY AND NIGHT

SWIMMING
POOL

DRESSING
ROOMS AND
LOCKERS

FILTERING PLANT CLEANSSES WATER
FOR SWIMMING POOL AND BATHS



Any Climate You Want

ALL THE WORLD'S HEALTH RESORTS PUT UNDER ONE ROOF

CURATIVE baths of the world's most famous spas, mineral waters from celebrated springs, and artificial climates to match seashore and mountains are brought together in a monster "artificial spa" designed by Dr. I. Goldmerstein of Paris, France, and Prof. Karl Stodieck of Berlin, Germany. Their plan would place all the benefits of expensive health resorts within reach of the inhabitants of large cities, they told a recent meeting of a scientific society in New York.

The project calls for a circular, glass-domed structure enclosing six and a half acres, to be erected at a cost of \$6,000,000 in the heart of the city, and to be open to the public for two periods daily. Paying a small admission fee and trading his street clothes for a bathing suit, a visitor finds himself in a vast amphitheater illuminated day and night by artificial sun lamps. A few steps across a sandy promenade bring him to the edge of a ring-shaped swimming pool nearly a quarter mile in circumference. After a swim, he may lounge on the sterilized, steam-heated sand

of a circular terraced island at the center of the pool, chatting with friends or enjoying the music of an orchestra while he basks under the ultra-violet lamps. A huge scenic panorama encircling the amphitheater, artfully lighted and painted with moving clouds by a revolving projector, completes his illusion of an outdoor setting. If the feeling of a wet bathing suit detracts from his pleasure, "hot box" compartments and ingenious presses dry him and his suit almost instantly.

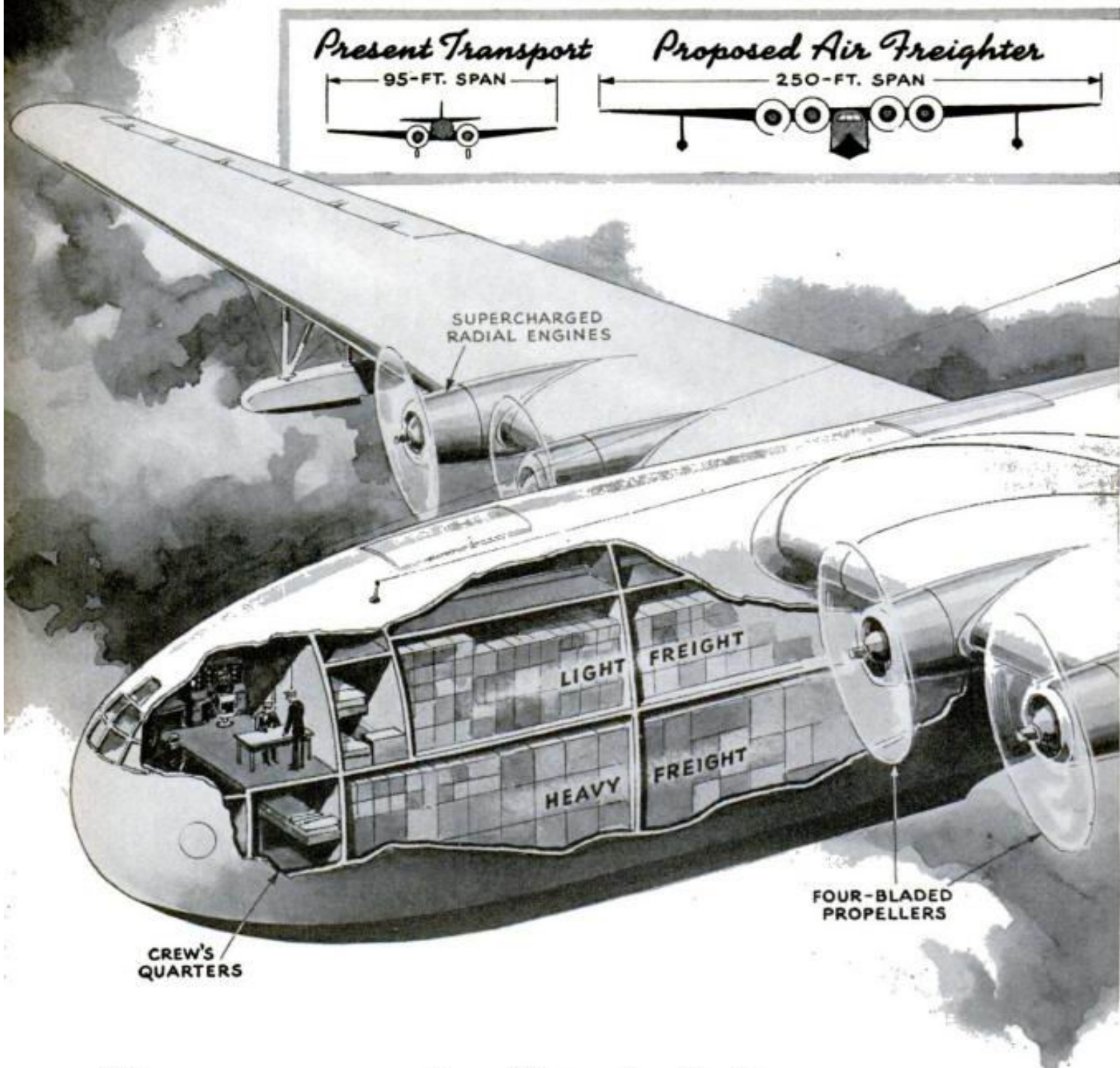
Booths surrounding this main hall offer the visitor the additional benefits, at charges depending upon the treatment, of medicinal baths of every description—with mineral waters, hot air, vapor, therapeutic lamps, and X-ray treatments. Air-conditioning magic brings him the mellow climate of Florida or the dry air of Arizona and New Mexico, while he sips bottled Carlsbad water from Czechoslovakia, Vichy water from France, Saratoga Springs water from New York State, or sulphur waters from Virginia.

Additional attractions include five gymnasiums, a movie theater, more

than a mile of walks along which to stroll, and a running track for those more athletically inclined, as well as sporting matches and other special diversions.

A maze of machinery behind the scenes caters to the needs of the thousands who flock to the health and recreation center. No sooner does the visitor doff his street attire than his linen is whisked away by an automatic aerial conveyor—to be returned to him freshly washed and ironed, from a subterranean laundry, when he is ready to depart. Sand travels back and forth, by way of an electric car and hoist, between the beaches and a sterilizer capable of disinfecting several freight-car loads a day with superheated steam at 300 degrees.

To overcome the disadvantage of hanging the quartz sun lamps at a great height, special chromium-plated reflectors multiply the effective illumination fivefold. A "Schwedler dome," an advanced architectural design of parabolic shape and great strength, solves the problem of providing a roof 600 feet in diameter and free from central supporting pillars.

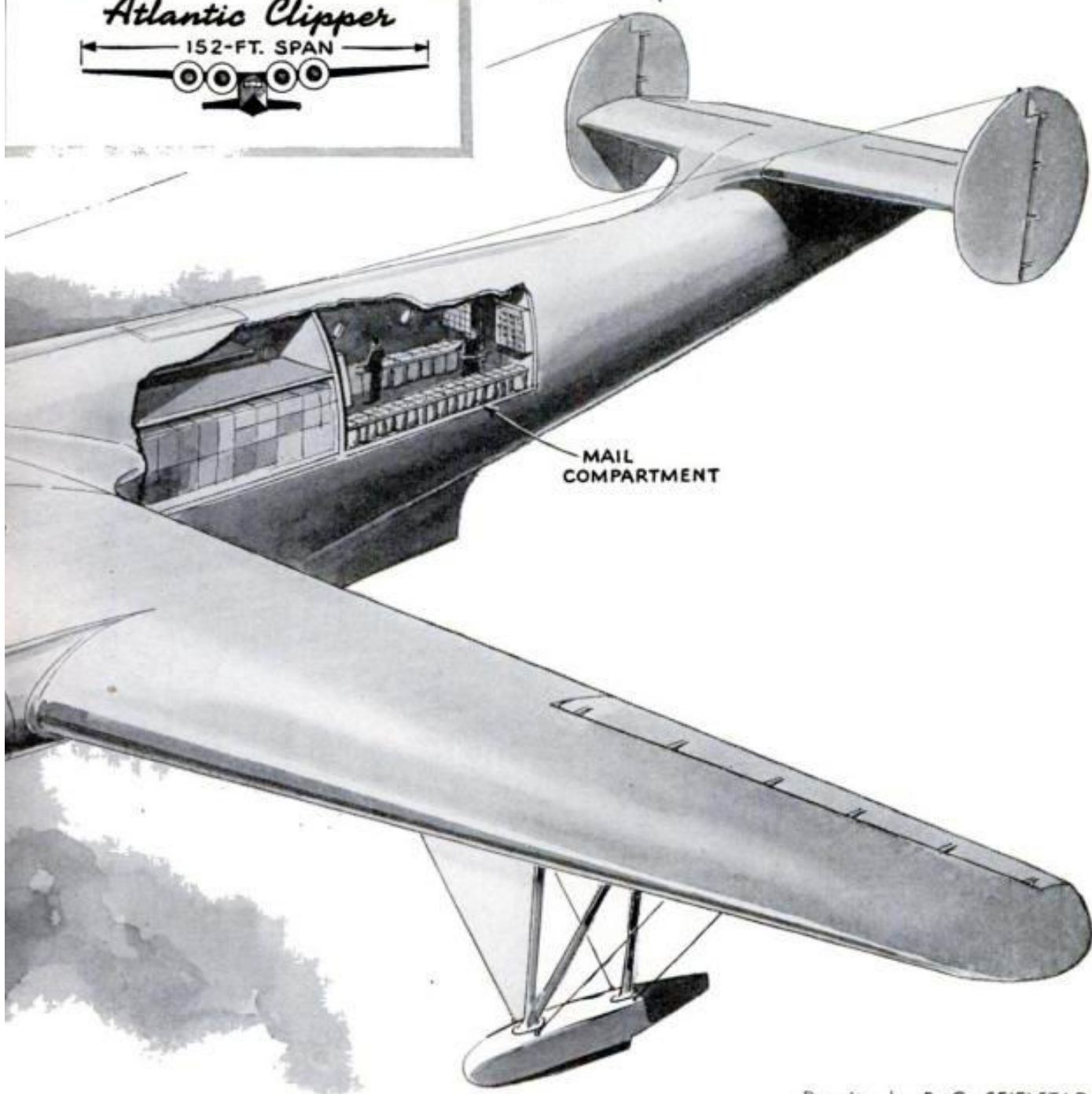


Tomorrow's Freighters

FREIGHTERS with wings, hauling 80-ton cargoes 3,500 miles without a stop, are more than an aviator's dream. According to Glenn L. Martin, Baltimore airplane manufacturer, they are a logical development of the aviation industry. The construction of planes capable of such performance, weighing 380,000 pounds, could be started tomorrow if somebody should order one.

Paradoxically, the destruction of the present war will speed the development of air freighters, their size to be determined by the business available, Martin believes. This is because the war is teaching airplane manu-

facturers to turn out bigger, better, and speedier planes by mass-production methods. It is pushing aeronautical research far beyond the point to which it would have progressed under more normal conditions in an equal period of time, and at the same time is destroying sea-borne cargo carriers at such a rate that a serious shortage already exists. Thus, when the war ends, exporters can be expected to turn to the air for a means of transportation that can be produced rapidly to replace the lost ships, and will also get the freight to its destination faster than would be possible by any



Drawing by B. G. SEIELSTAD

method of transportation on land or water.

Martin, who flew an early "air express" in 1912 when he carried newspapers and mail in a plane, and whose factory has turned out some of the world's biggest planes, is not telling what the detailed specifications of a 190-ton air freighter would be. But he already has the drawings for a 65-ton luxury passenger airliner, a step in the right direction, and his factory is building a plane, presumably a bomber, which will be the U. S. Navy's largest flying boat.

He has no fear that postwar conditions will cause a slump in the aviation industry.

Before the war began, he points out, it was the nation's fastest-growing industry. War-stimulated growth will enable it to pick up commercial plane production when the war ends years ahead, in progress, of where it would otherwise have been.

The not-far-distant future will see a system of harbors, landing fields, docks, and warehouses serving air freighters as railroads and ships are now served, Martin believes. He sees in air freight a new frontier for Americans, with thousands of new jobs for workers and vast new fields of investment for capital.

The Tallest by Fifteen Stories

CONSTRUCTION soon will begin on what will be the world's largest and tallest building—the Chicago Tower and Apparel Manufacturers' Mart. Seventy-five stories high and covering two city blocks, it will house in addition to offices and stores, a 440-room hotel, a 1,024-car garage, two clubs, a hospital, swimming pools, gymnasiums, and even a small golf course.

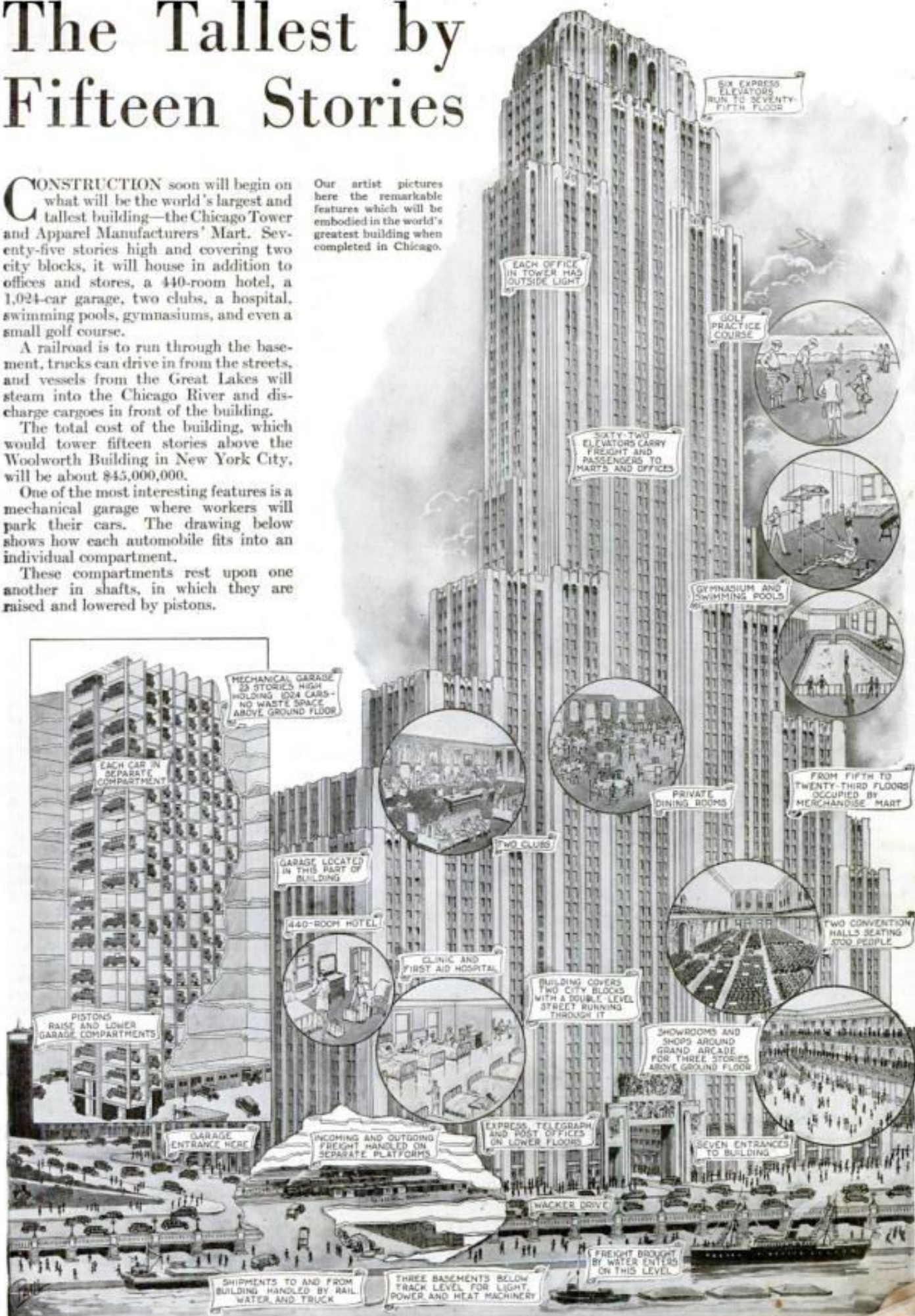
A railroad is to run through the basement, trucks can drive in from the streets, and vessels from the Great Lakes will steam into the Chicago River and discharge cargoes in front of the building.

The total cost of the building, which would tower fifteen stories above the Woolworth Building in New York City, will be about \$45,000,000.

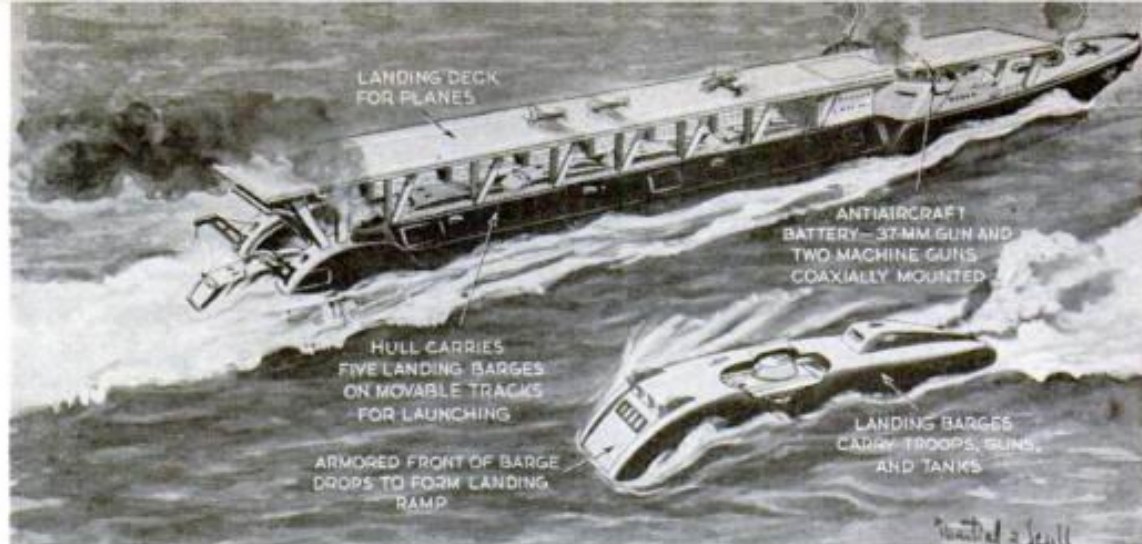
One of the most interesting features is a mechanical garage where workers will park their cars. The drawing below shows how each automobile fits into an individual compartment.

These compartments rest upon one another in shafts, in which they are raised and lowered by pistons.

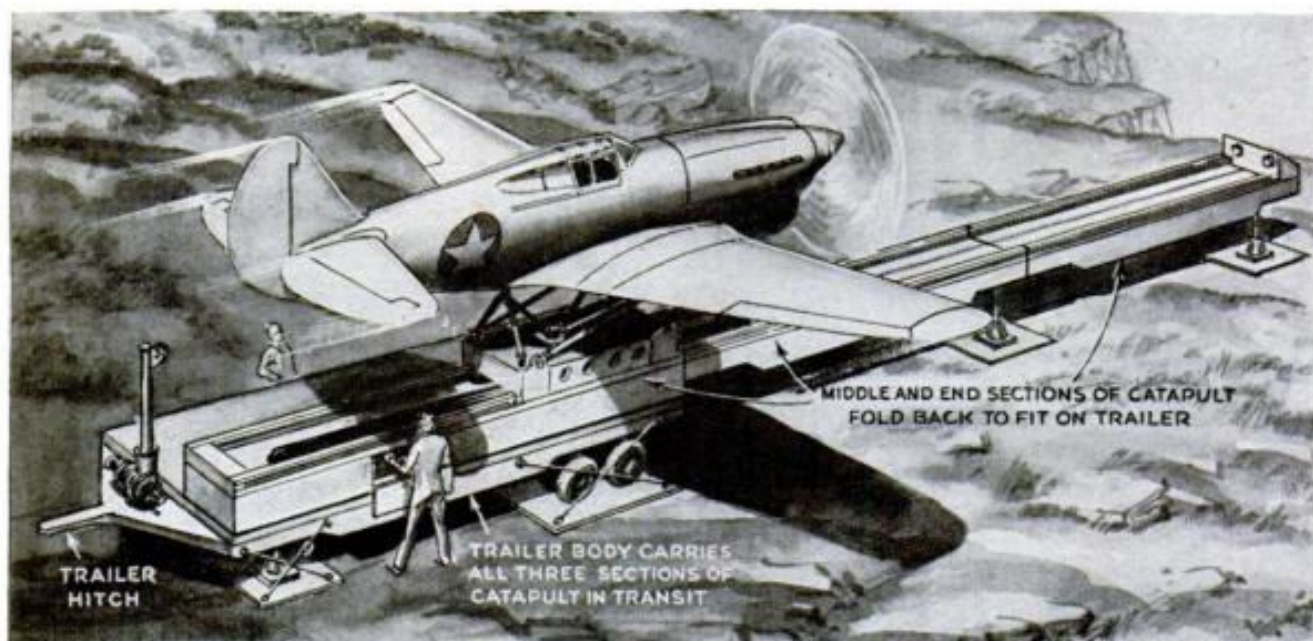
Our artist pictures here the remarkable features which will be embodied in the world's greatest building when completed in Chicago.



WAR IDEAS

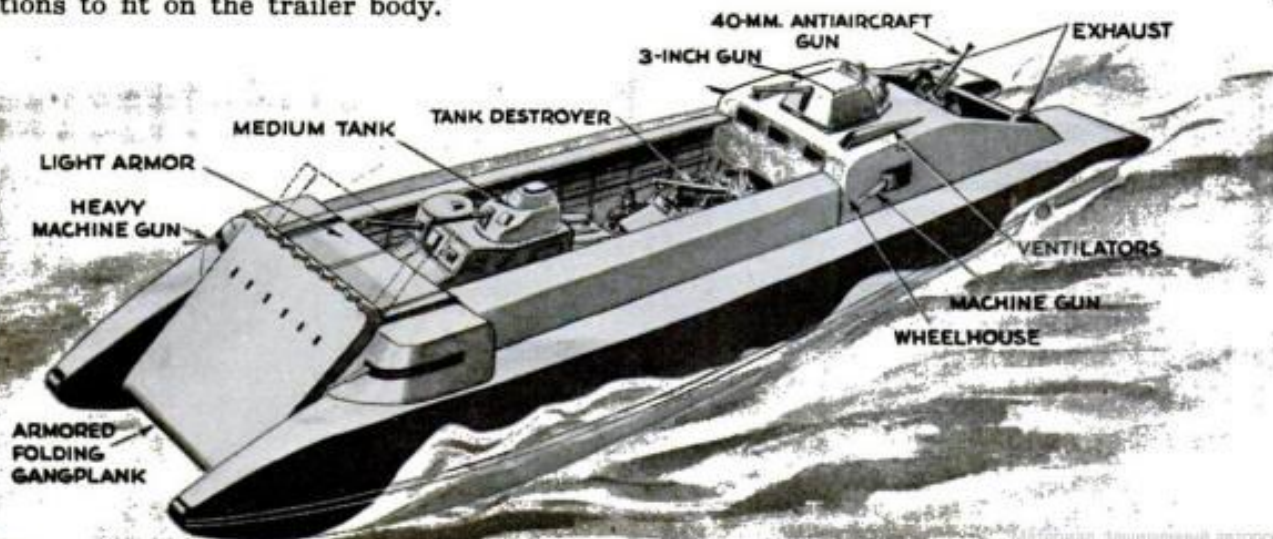


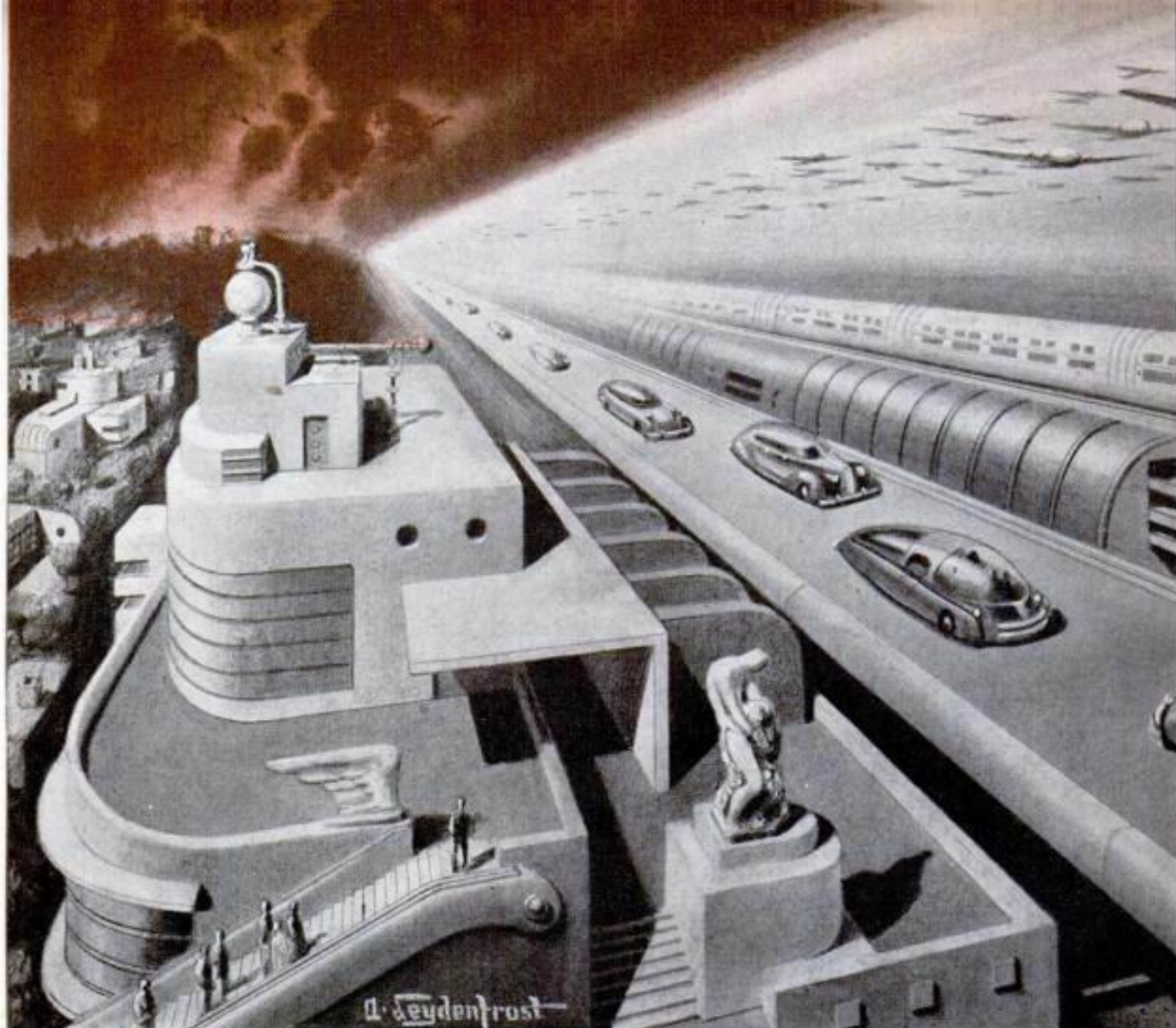
BARGE AND AIRCRAFT CARRIER, this invasion ship, conceived by Jacques Martial and Robert C. Skull, industrial designers, has combination smashing power. Its deck holds 15 to 20 bombers and protecting fighters. Under the deck are tracks for five barges, and retrieving cranes. The ship mounts three triple 37-mm. anti-aircraft guns, and can carry torpedo boats instead of barges.



TRAILER PLANE CATAPULTS, such as the invention depicted above, may be hauled into place by truck, and fighting planes launched by them from front-line positions where it would be impracticable to clear out even temporary flying fields. The runway consists of a jointed track which folds in three sections to fit on the trailer body.

LANDING BARGE. This open-top landing barge, capable of carrying a medium tank and a self-propelled 75-mm. gun, is heavily armed. Besides four heavy machine guns and an anti-aircraft gun aft, it also mounts a 3-in. gun in a movable turret. The design is offered by Martial and Skull.





War's End *will*

By JOHN H. WALKER

AFTER this war is won, the American people should be able to travel faster and live better than ever before. The money and energy being poured into our war effort now will pay us dividends years after the victory itself.

Three main factors in the war effort guarantee a better life for Americans:

New Plant.

New Discoveries.

New Skills.

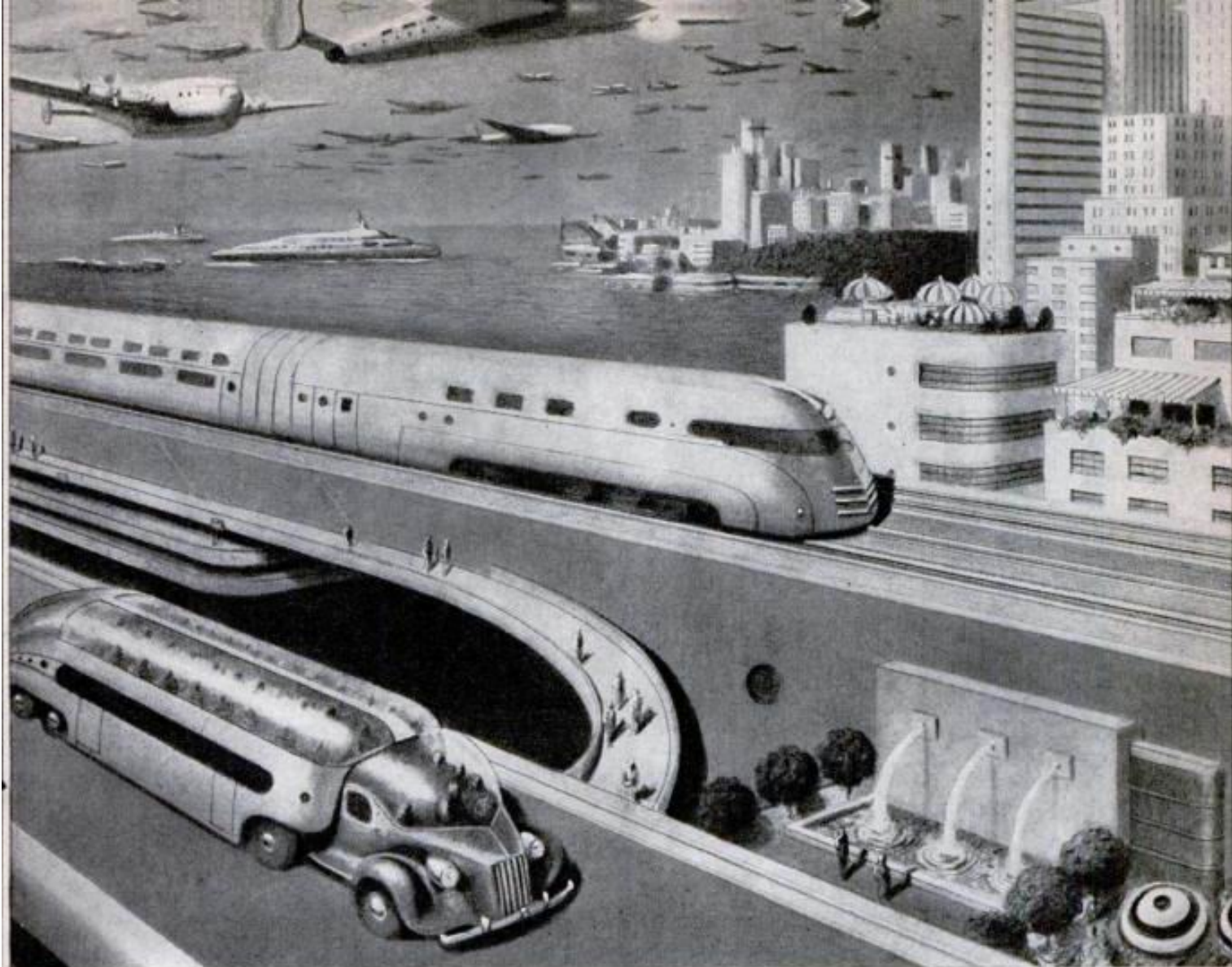
War secrecy bars any complete compilation of the tremendous plant expansion carried on in the past two years. Some of the new factories and arsenals have been well publicized, while others have been discreetly played down to avoid attracting the attention of saboteurs or revealing too much about our

war-material manufacturing schedules. But that expansion has been on a huge scale. One good example which can be cited is that of the shipbuilding industry, which has expanded to something like 600 percent of its former capacity.

We have entire new factories in the Middle West, built to produce tanks, bombing planes, and engines. And very much in the public eye are the new oil pipe lines being built to supplement our existing system linking oil fields to industrial areas.

All this new plant is destined to become a permanent part of our industrial heritage. The problem of reconversion to civilian use may be a knotty one in some specialized cases, yet the fact remains that we will have this new equipment to use.

New discoveries most certainly will flow into the current of our economic life under



bring a better life

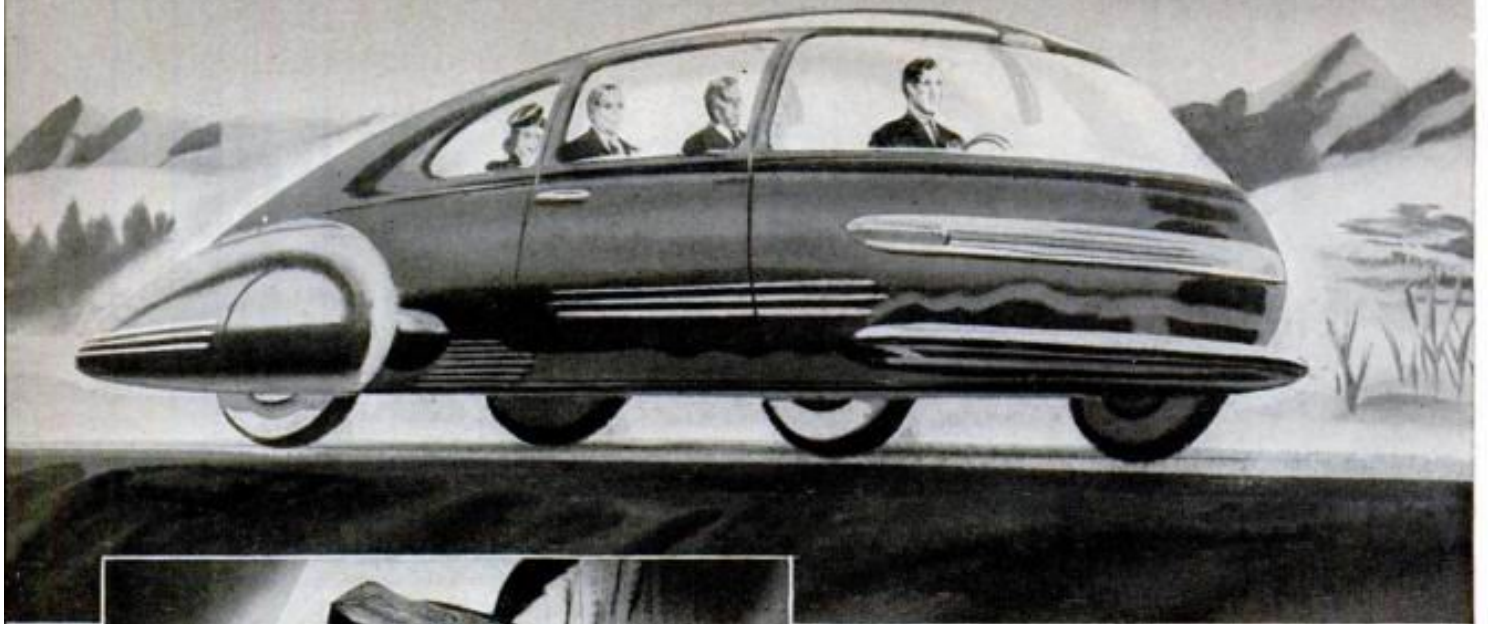
the pressure of greatly increased wartime research by almost every branch of industry. Chemistry, metals, plastics and glass, electricity and radio, construction, communication and transportation, fabrics and food and medical science—all these and virtually every other field of human activity will experience the forward thrust of research and development carried out under forced draft.

Along with this forced advance of technology will go a wartime pooling of brains and patents in industry, and it is not too much to say that before the war is over millions of Americans, young and old, will have learned some kind of new skills, making them better fitted to work and produce for the greater wealth of the whole nation.

New skills not only make new industries possible; they make them inevitable. Take

one example: Hundreds of thousands of young Americans will have learned how to fly or navigate or overhaul airplanes in this war. Afterward they will want light planes to fly, even if they return to totally different civilian work. That demand will create a private-airplane industry far beyond anything we have known. Many aeronautical scientists believe that the plane these people will really want is a workable helicopter type, able to land and take off almost vertically, at dead slow speed. And that, in turn, is a problem for research; there will be no lack of plant to build the ships.

We can't look far enough into the mist of the future to assemble any detailed list of things to come. Yet the broad general outlines of a better life are clearly distinguishable. Our interpretation of these outlines has been based almost entirely on material



Rayon-cord fabric is making Army tires stronger. After the war, long-wearing synthetic-rubber tires with rayon cord will be available to civilians

supplied by the major U. S. industrial concerns, research organizations, designers, engineers, and Government technical bureaus.

Right at the start it can be said with certainty that our life in the future will be characterized by greatly speeded-up transportation and the extensive use of new building and fabricating materials, both natural and synthetic.

No field has more dramatic possibilities than that of transportation, and the greatest developments, of course, will come in the air.

The war's end will find America with many thousands of bombing and air-transport planes, some of which will be almost immediately convertible to peacetime use.

In addition, we will have unrivaled facilities for building and designing planes, and it is certain that entirely new types must and will be developed to meet the keen international competition which is

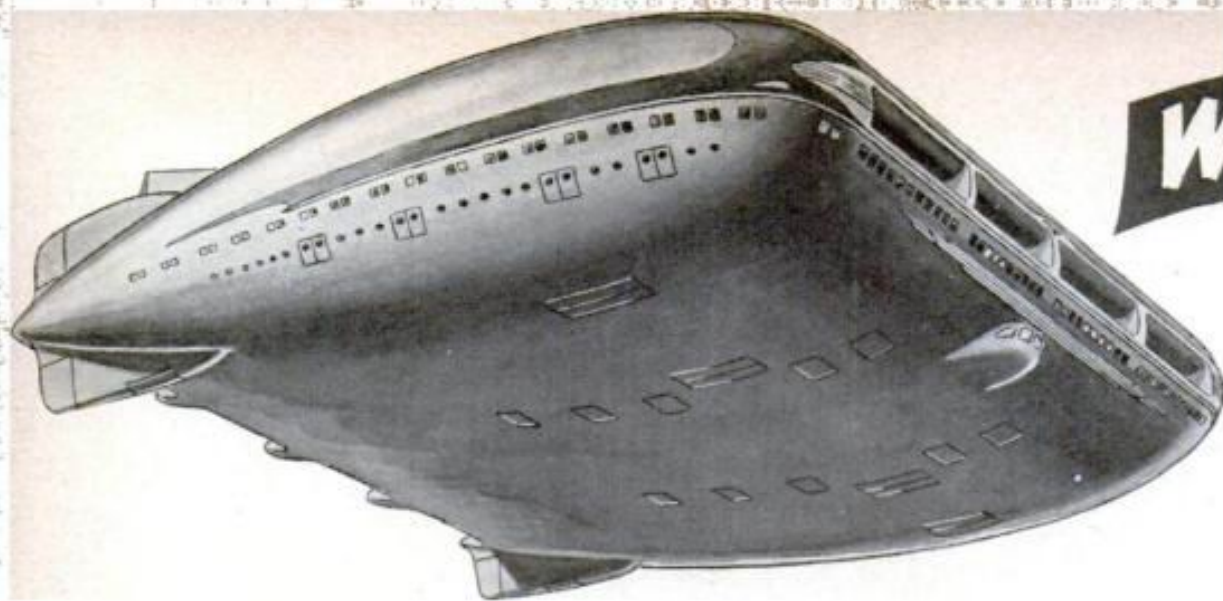
TOMORROW'S CAR. Automotive engineers looking ahead to postwar designs foresee lighter, cheaper, and safer cars. Plastic tops, frameless chassis, hydraulic drives, superchargers, lighter engines, and streamline bodies are slated for after the war. As for price—estimates range from \$500 to \$1,000 for small cars, and from \$1,200 to \$3,000 for larger models. As for economy—the smaller cars will give at least 30 miles to the gallon while even the larger cars will be expected to give 20 miles. Regular-grade gasoline will be 80 octane; premium grade, 100 octane

sure to spring up. We will have one other great advantage, already in being, in our elaborate Army Air Transport Service, with all the major U. S.

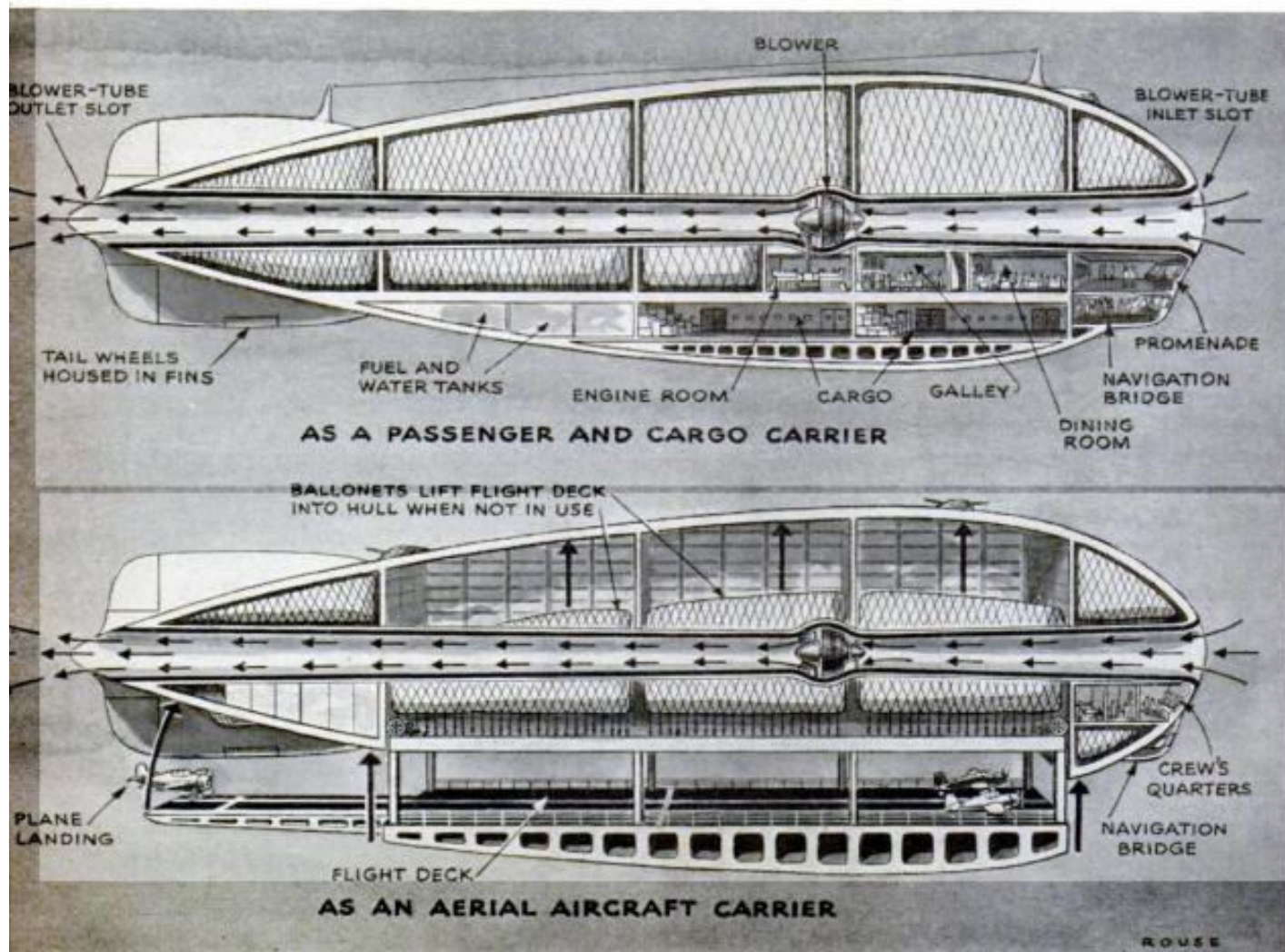
air lines co-operating in maintaining service all over the world on a scale of organization scarcely dreamed of three years ago.

The cargo plane of the future will be specially designed for its work, will have a very high lift factor, will have both nose and side hatches for loading cargo, and will have a relatively low landing speed to get into small airfields.

If airmen are inclined to speculate mostly on their future cargo business it is not because they aren't interested in passenger traffic, but rather because they take it pretty much for granted that planes will be the normal medium of high-speed travel over any reasonably long distances. Giant passenger planes are sure to come along; there can't be a designer in the business who hasn't at least sketched out an idea for a super-airliner complete with sun lounge, promenade deck, eight engines, etc., and some of these designs had been well publicized even before the war. Most



WAR



FLYING AIRCRAFT CARRIERS and huge troop and cargo air transports with a range of 8,000 miles have been designed by Horace Chapman Young and Eric Langlands as combinations of airship and airplane. The Airwing, as the craft is called, is built as a flying wing with space within its single-wing body for helium, fuel, crew, and pay load and tunnels in which propellers or blowers operate.

This wind-tunnel operation is based on the principle that the plane will both pull and push itself forward—pulling through suction caused by a semivacuum created in front, and driving by exhaust pressure at the rear.

The helium gives it additional lifting power, making a total load of 63 tons possible for a ship 250 feet square and 62½ feet in height. A troop transport of the same size would accommodate 300 soldiers fully equipped for service abroad. The aircraft carrier is designed with a flight deck 180 feet wide by 200 feet long that could be lowered below the hull to allow 12 fighter planes to take off and land.

Maximum speed is estimated at 240 miles an hour, take-off speed at 30, and landing speed at 20. The Airwing could cruise 270 hours at 30 miles an hour.



A NAZI IDEA FOR AN

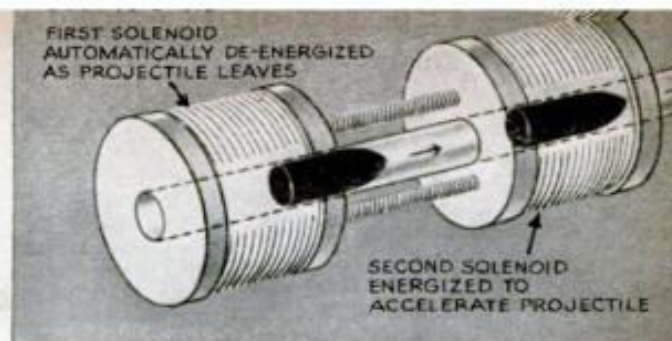
Electric Gun

IMAGINE a rapid-firing electric cannon, capable of raining 750 six-inch shells a minute upon a target 90 miles away! Out-ranging the long-distance guns that bombarded Paris in the First World War, such a weapon is proposed in a French edition of the German periodical "Signal." Is artillery of this kind to be a possibility of the future?

As depicted, the scheme calls for a huge gun with a thin 230-foot barrel. Solenoids, or coreless electromagnets, encircle the tube at regular intervals from its breech to its muzzle. When a firing switch is closed, the first solenoid magnetically attracts the missile and starts it on its way. As the shell passes through it, this solenoid goes dead

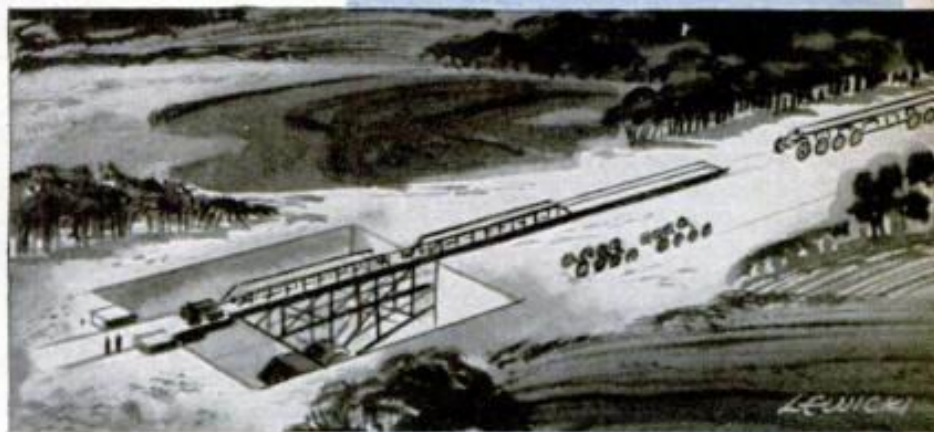
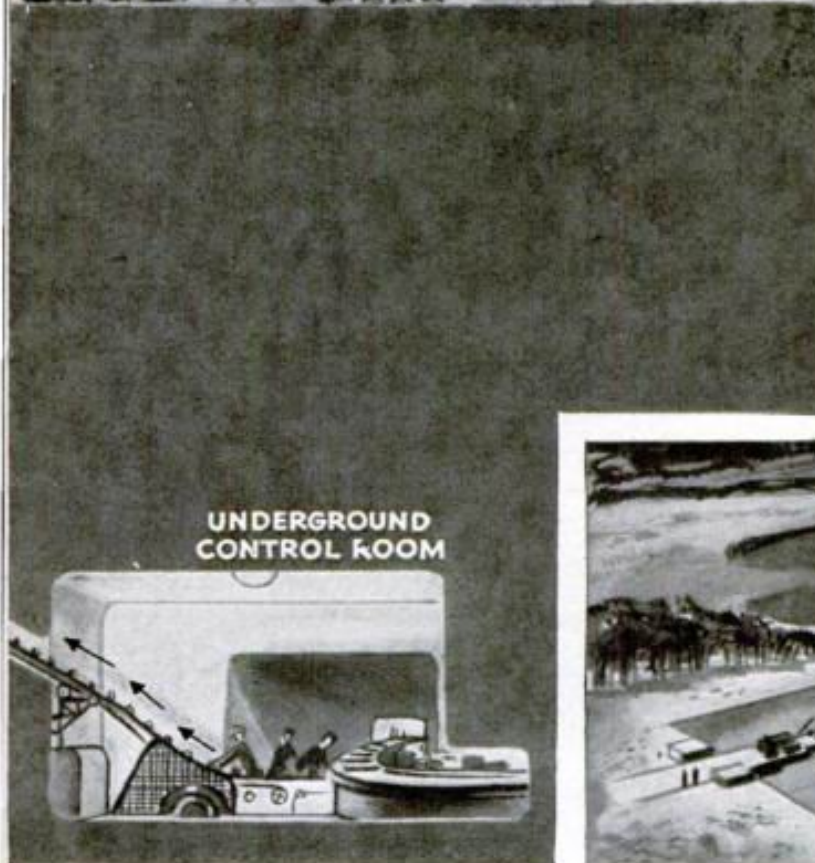
and the next one takes up the pull, until successive impulses give the projectile a muzzle velocity of more than a mile a second. A high-speed automatic conveyor feeds ammunition. When not firing, the gun lowers for concealment beneath camouflaged covers.

Formidable as it sounds, the idea invites critical analysis. First, just what is this gun intended to do? At its extreme range, precision firing upon small targets such as ships and troop concentrations would be out of the question. A more likely task would be to shell a large city at random. London could be bombarded from clear across the Channel. But here the gun takes on a job for which bombing planes are pre-eminently suited. Presumably the cannon would be of



MAGNETISM REPLACES POWDER IN THIS NAZI DREAM WEAPON

Looking more like a drawbridge than a piece of artillery, the odd structure at the left is our artist's conception of the electromagnetic cannon proposed in a German publication, as it rises from concealment to hurl 750 six-inch shells a minute at a target 90 miles away. Subterranean, bomb-proof galleries house the control room and ammunition magazine, from which an endless conveyor feeds shells automatically to the gun. Spaced along the slender tube as seen above, coreless electromagnets are energized in rapid succession to whip the projectiles through the barrel, which they leave with a muzzle velocity of more than a mile a second. Absence of



most interest to a belligerent shorn of air power. The damage inflicted by one of its high-explosive shells would be exceeded by an air bomb of only 250 pounds—a modest size, indeed, compared to a modern 4,000-pound "block buster."

An embarrassing problem remains—where to get the 1,000,000 kilowatts of power needed to operate the gun. No generating station in all of Germany has this capacity. Interconnected sources of current might be used, but only at the cost of a "blackout" of vital Axis industries using electric power. Perhaps the grandiose idea simply needs radical scaling down. Small electric guns have been devised by inventors in many lands, and some model may yet compete with those that use gunpowder.

explosive blast makes a thick barrel unnecessary, and recoil takes effect only on the magnets and their supporting framework. Shells of special design could be rotated electrically to steady their flight, the effect obtained by rifling in an ordinary cannon. A vulnerable target for hostile bombers because of its fragile construction, the gun may be shifted from one emplacement to another in three sections, on trailers drawn by powerful towing trucks. The sketch above shows the 230-foot tube being reassembled at an emplacement. For comparison, a conventional gun of the same caliber has a 20-foot barrel and a maximum range of about 14 miles

Nerve Center of the Fighting Forces

WASHINGTON'S COLOSSAL PENTAGON BUILDING

By ALDEN P. ARMAGNAC

YOU stop at a reception desk and ask to see the Army officer with whom you have an appointment. Casually the operator calls Extension 73,759.

"His office is 2E250," she tells you. "Please wait for an escort."

You are glad to have a guide. You are in the largest building in the world, the Army's newly completed Pentagon Building at Arlington, Va. Nerve center of our fighting forces all over the world, it now houses War Department personnel formerly scattered throughout Washington, D. C., in 17 different buildings. The result of this centralization, which effects a tremendous gain in efficiency in the department's job of directing a global war, is a city of 40,000 workers under a single roof.

Your approach gave you a view of a low-lying building, faced with buff limestone and roofed with dark-green slate—remarkable only for its great length. Actually you saw only one or two of its five concentric divisions that ring a central court like a medieval fortress. The structure camouflages its sheer immensity. Once inside, you experience something of the sensation of a tourist viewing Niagara Falls for the first time. You walk more than a city block, part of another—and even then you find that you

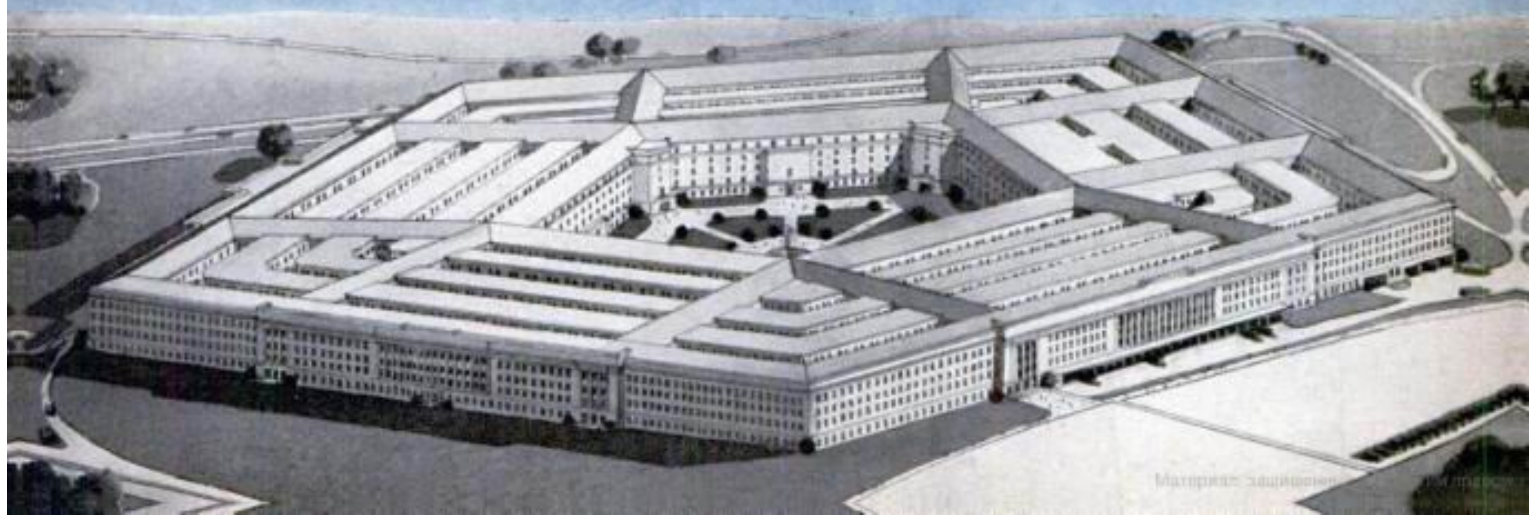
have only reached the six-acre central court.

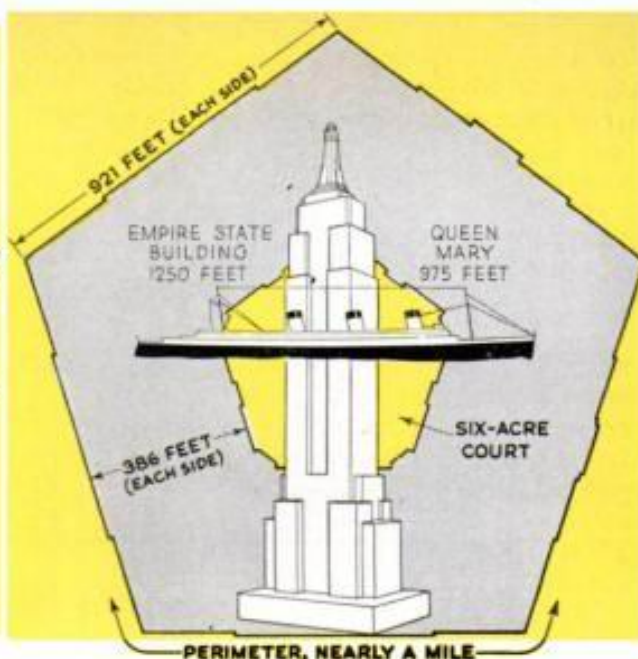
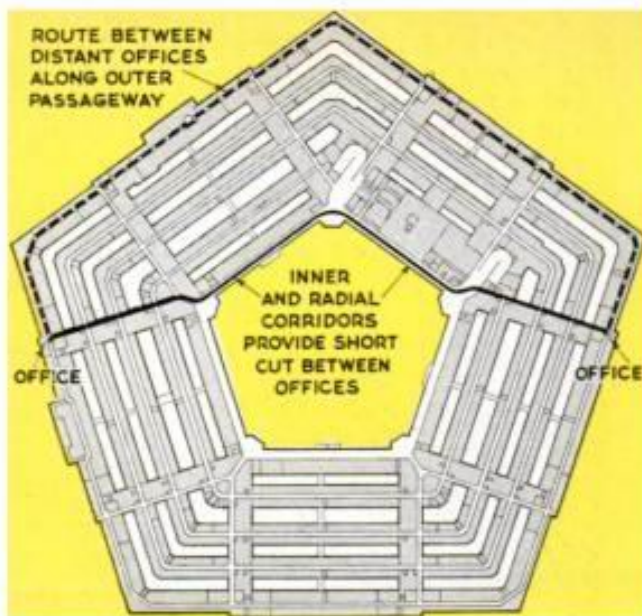
Torrents of humanity swirl through its corridors—Army officers and men, civilian specialists, stenographers, cafeteria waitresses, switchboard operators, messengers. At once you are impressed by the absence of confusion. Everyone seems to know exactly where he is going, how to get there—and keeps moving. A maze of passageways that first bewildered you turns out, on further acquaintance, to be a masterpiece of scientific design.

Planning this architect's dream called for the aid of geometry. In theory a perfect circle would be ideal for access to all offices. More practical structurally, a ring of straight sections would approach a circle closely enough. Thus evolved, upon the drafting board, the five-sided or pentagon shape from which the giant building takes its name. Working day and night, 15,000 men have transformed the dream into reality in the record-shattering time of 15 months.

From a main corridor bordering the inner court, numbered corridors extend radially to the outer rings. They intersect concentric, lettered passageways in each ring, forming a spider-web pattern. The main, inner corridor becomes a short cut between distant parts of the building. Though the structure measures nearly a mile in (CONTINUED)

Here in this five-sided building, across the Potomac from the city of Washington, is the nerve center of our fighting forces—the offices of the War Department. Measuring nearly a mile in circumference, the building still provides easy access from one office to another, and easy access, too, to the capital





This pentagon design was chosen to save steps in going about the huge building. Passageways are scientifically laid out so that maximum walking distance on any of the five floors is 1,800 feet

perimeter, the maximum walking distance between two offices on the same floor is 1,800 feet, and this is an exceptional figure.

The mystifying symbol "2E250" supplies exact directions for getting to the office it designates. Translated, it becomes, "Second floor, Ring E, Corridor 2," and the remaining numbers indicate the door.

Because the \$49,000,000 Pentagon Building is a low one, it has been possible to dispense almost entirely with passenger elevators, yielding the dual advantage of saving space and of avoiding delays and congestion. For vertical travel, occupants use ramps and escalators.

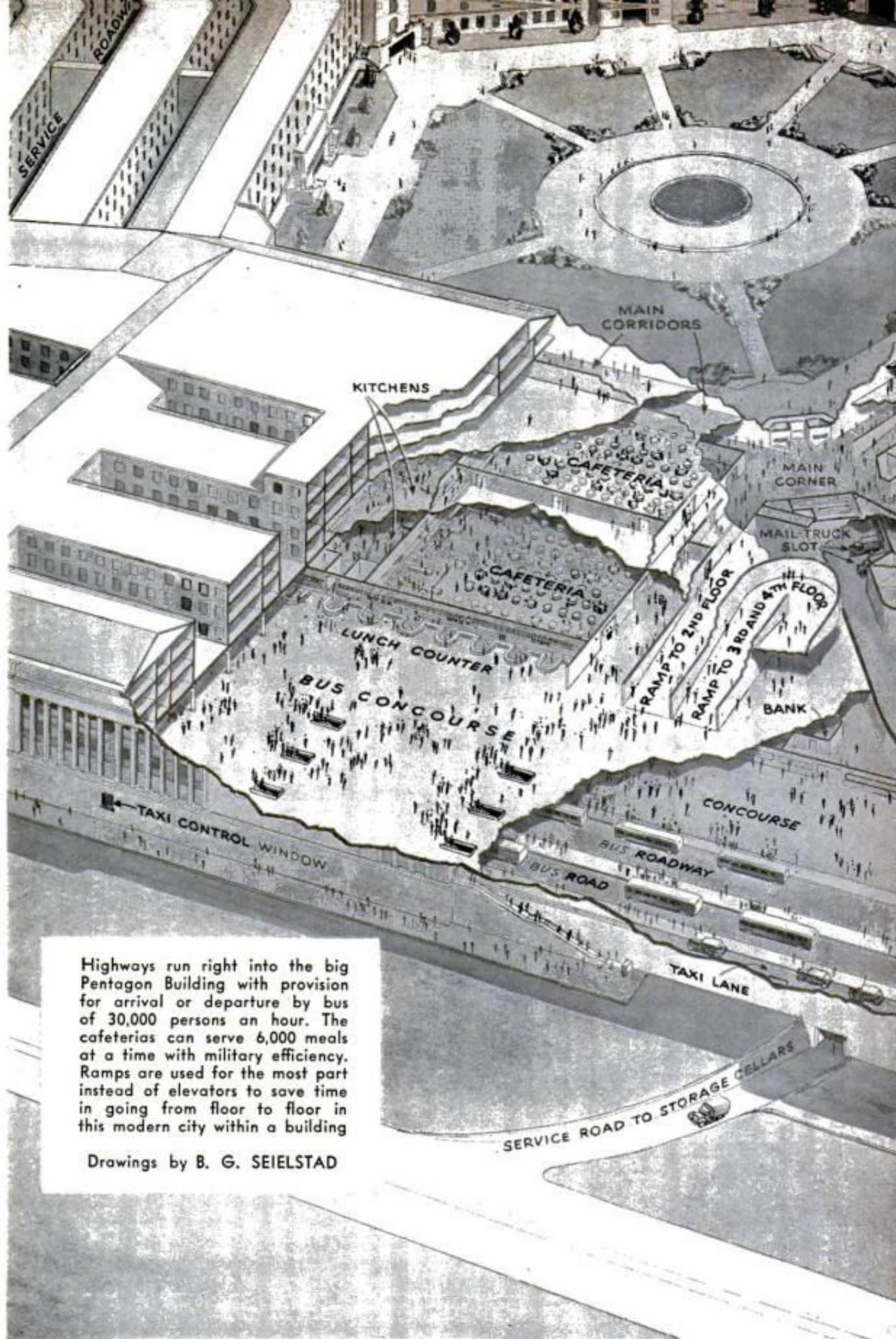
Compared with the height of the big Empire State Building or the length of the liner Queen Mary, the immensity of the area covered is easily seen. The total floor space is 4,000,000 square feet

Of the building's occupants, the most prominent include Henry L. Stimson, Secretary of War, and Gen. George C. Marshall, Chief of Staff of the United States Army. Allocation of offices in the various parts of the building was carefully planned to facilitate co-operation between officials and departments in related fields. Each floor has walls and pillars of a distinguishing color. Brown identifies the first floor; green, the second or main floor; red, the third floor; gray, the fourth floor; and blue, the fifth floor.

Offices range in size from small rooms to working spaces as large as 50 by 400 feet.

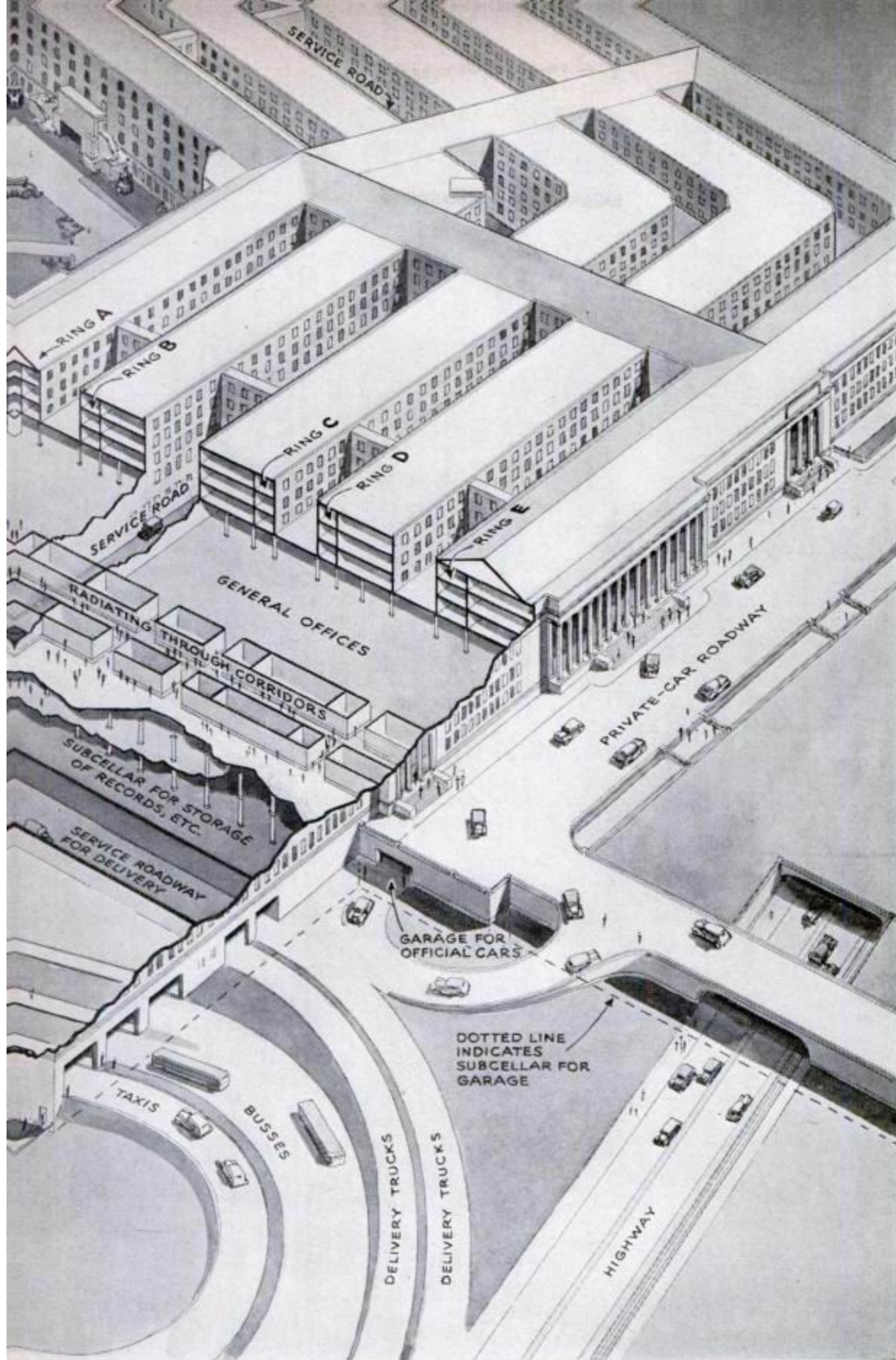
Providing telephone service for the new \$35,000,000 War Department building in Arlington, Va., was a gigantic undertaking in itself. Here one of two barges employed starts paying off six of the twelve cables to Washington across the Potomac. The lines lay in 2,000-foot trenches dredged in the river bed

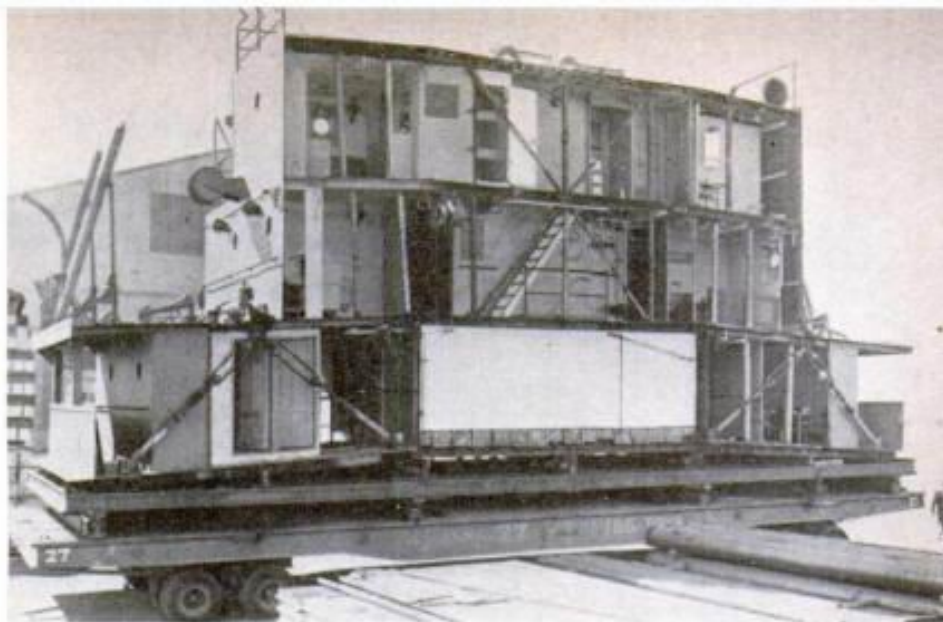




Highways run right into the big Pentagon Building with provision for arrival or departure by bus of 30,000 persons an hour. The cafeterias can serve 6,000 meals at a time with military efficiency. Ramps are used for the most part instead of elevators to save time in going from floor to floor in this modern city within a building

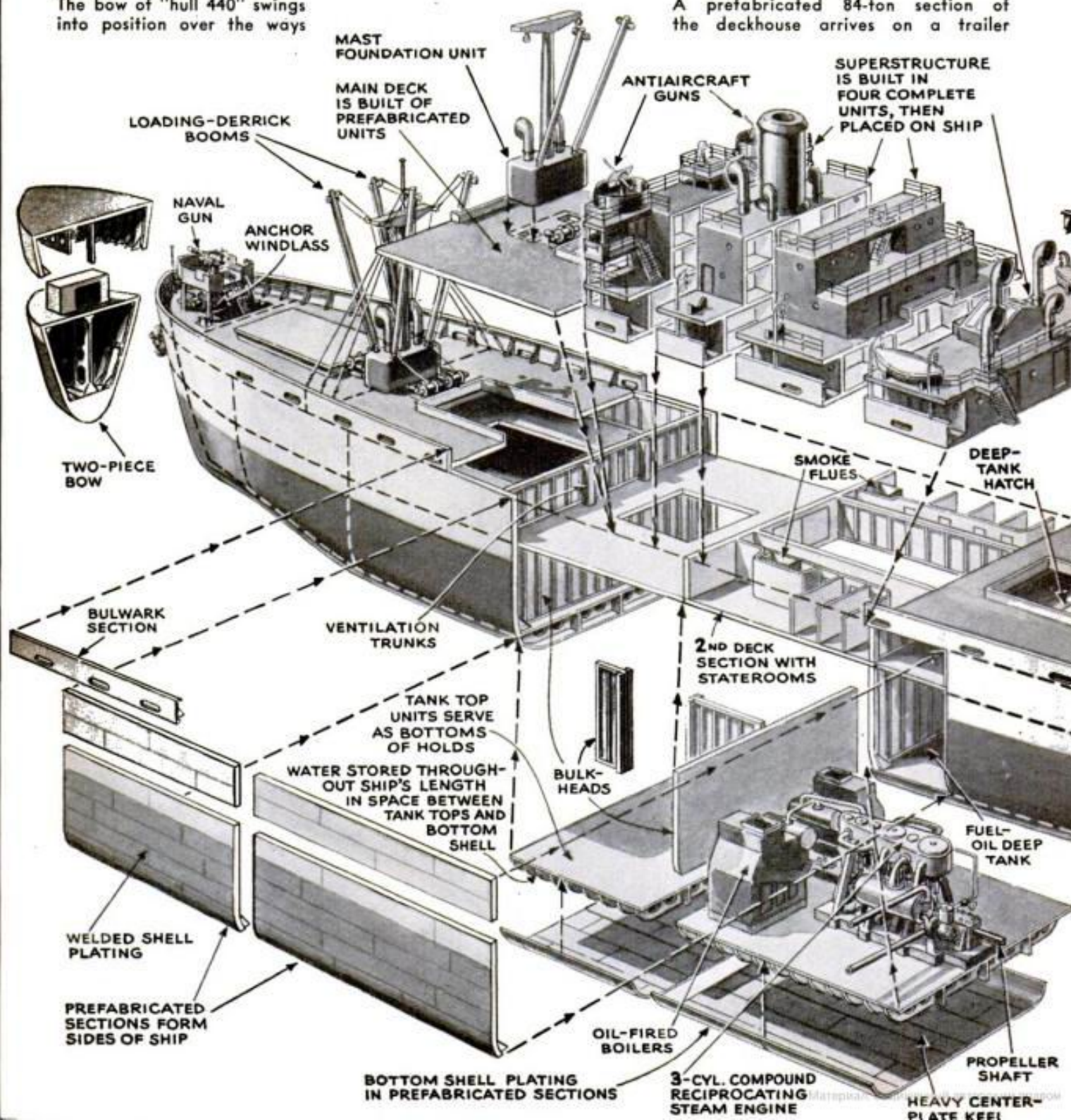
Drawings by B. G. SEIELSTAD





The bow of "hull 440" swings into position over the ways

A prefabricated 84-ton section of the deckhouse arrives on a trailer

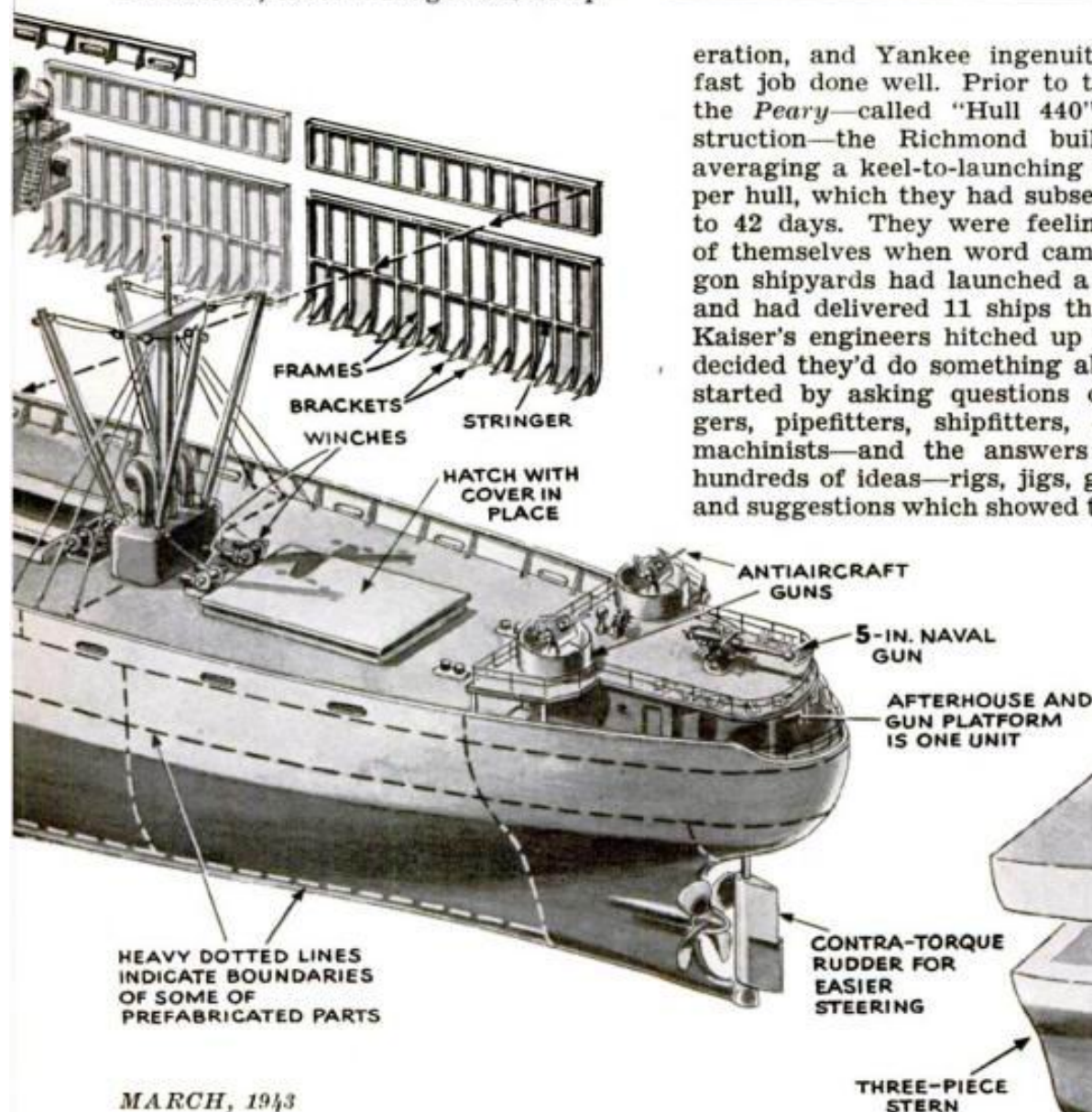
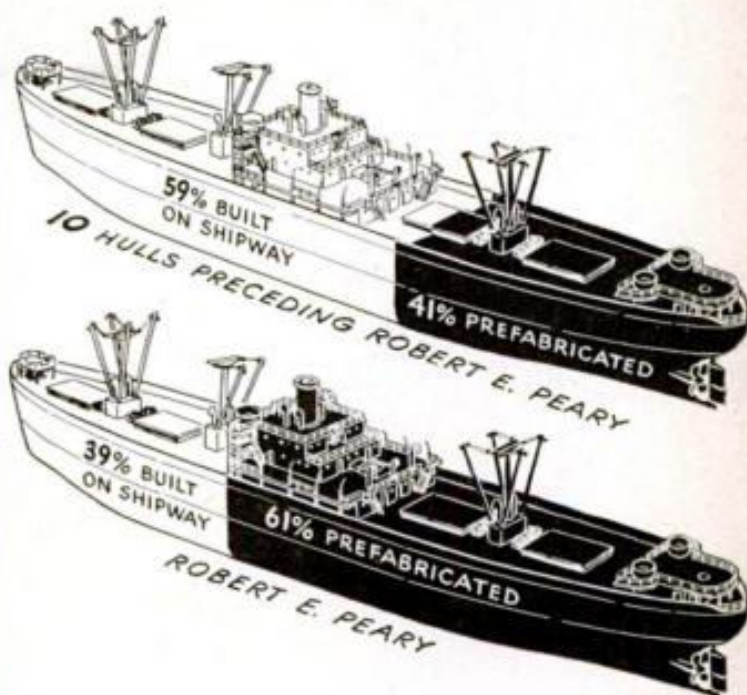


WHAT HAPPENS WHEN KAISER BUILDS A SHIP

A JIGSAW PUZZLE OF STEEL,
WITH A QUARTER OF A
MILLION PIECES AND 97 PRE-
FABRICATED SECTIONS, FORMS
A NEW VESSEL FOR VICTORY

DRAWINGS BY STEWART ROUSE

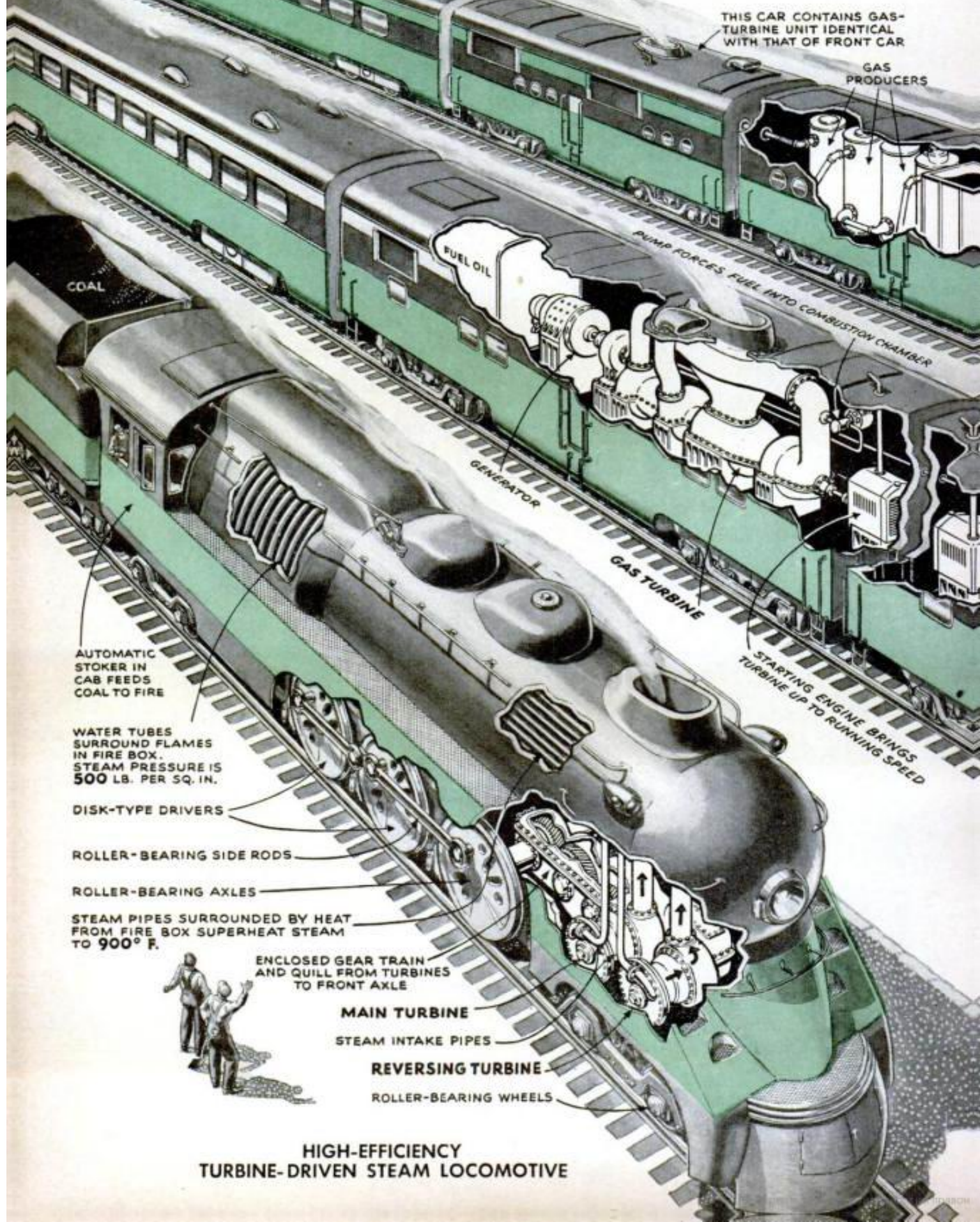
WHEN the 10,500-ton *Robert E. Peary*, on November 12, 1942, slid down way No. 1 of Henry J. Kaiser's Richmond shipyard after being on the ways only four days, 15 hours, and 26 minutes, it did more than set a world's record in speedy shipbuilding. It set records in prefabrication, labor-management co-op-



eration, and Yankee ingenuity in getting a fast job done well. Prior to the launching of the *Peary*—called "Hull 440" while in construction—the Richmond builders had been averaging a keel-to-launching time of 57 days per hull, which they had subsequently lowered to 42 days. They were feeling pretty proud of themselves when word came that the Oregon shipyards had launched a hull in 10 days and had delivered 11 ships that same month. Kaiser's engineers hitched up their pants and decided they'd do something about that. They started by asking questions of welders, riggers, pipefitters, shipfitters, draftsmen, and machinists—and the answers came back in hundreds of ideas—rigs, jigs, gadgets, devices, and suggestions which showed that the workers

MARCH, 1943

Postwar Locomotives Will Hit New High in Power and Efficiency



By CAPT. W. MACK ANGAS

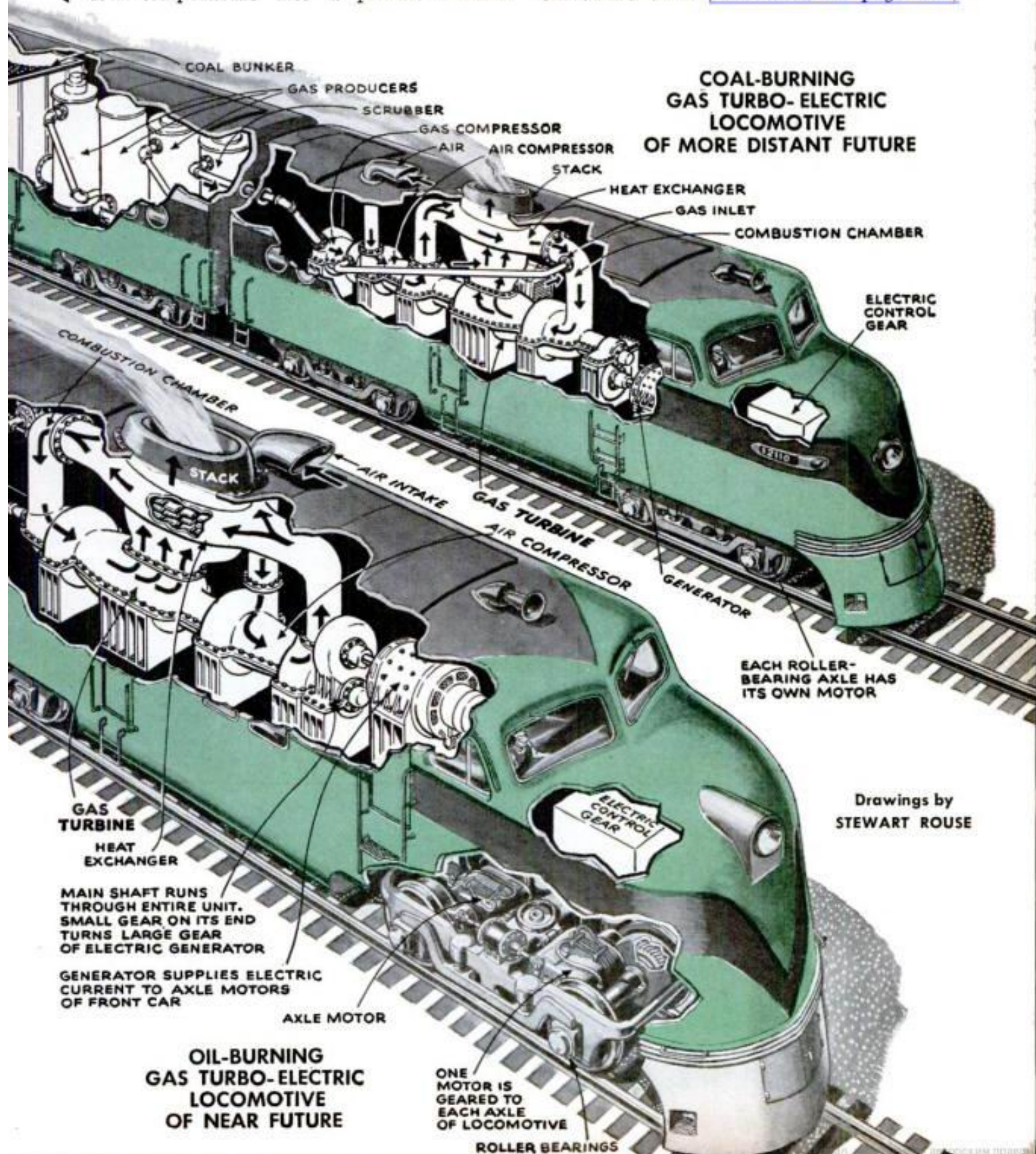
Civil Engineer Corps, U.S.N.

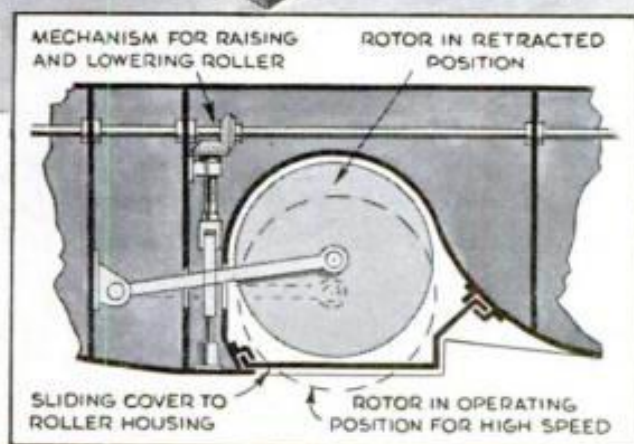
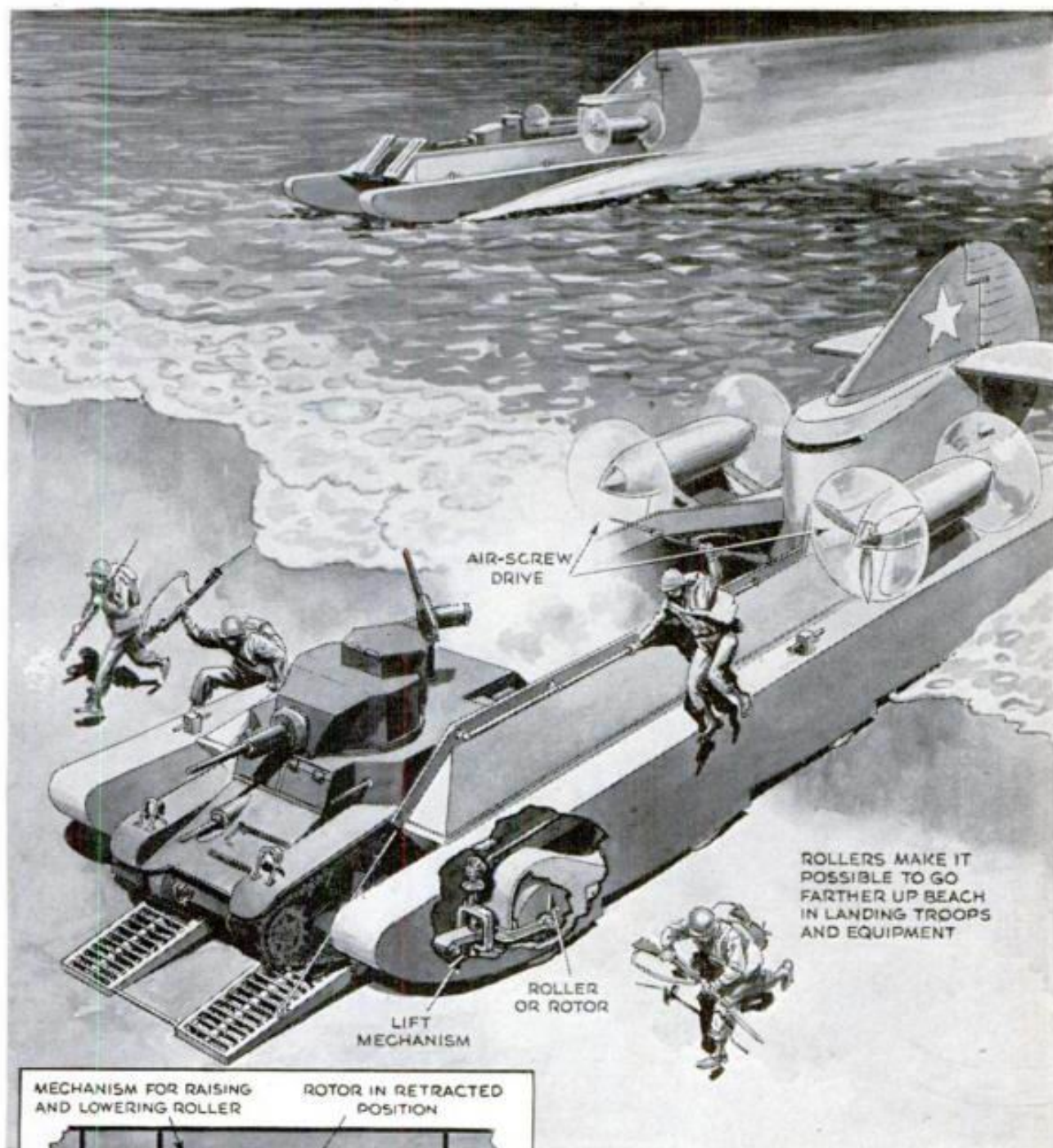
WHEN the new techniques and materials developed by the war are finally directed toward industrial problems of peacetime, one of the machines most likely to experience radical departures in design and construction is the railroad locomotive.

The familiar steam locomotive will still be with us for a while—but it, too, will undergo revolutionary changes. Air and water-cooled condensers that increase the efficiency of stationary and marine steam engines by permitting them to exhaust at low temperature into a partial vacuum

The opinions expressed in the following article are the author's, and should not be interpreted as those of any department of the Government.

have, as yet, proved impractical for use on a locomotive. But there is no reason why the engine's efficiency cannot be increased by stepping up the pressure and temperature of the steam that drives it. A fire-tube boiler used in conjunction with a water-tube fire box, such as has already been developed, may readily raise current pressures of about 250 pounds per square inch to 400 or even 500 pounds—with a superheater to raise the steam's temperature from 600 to over 750 degrees F. Since steam much over the latter tem. *(Continued on page 210)*

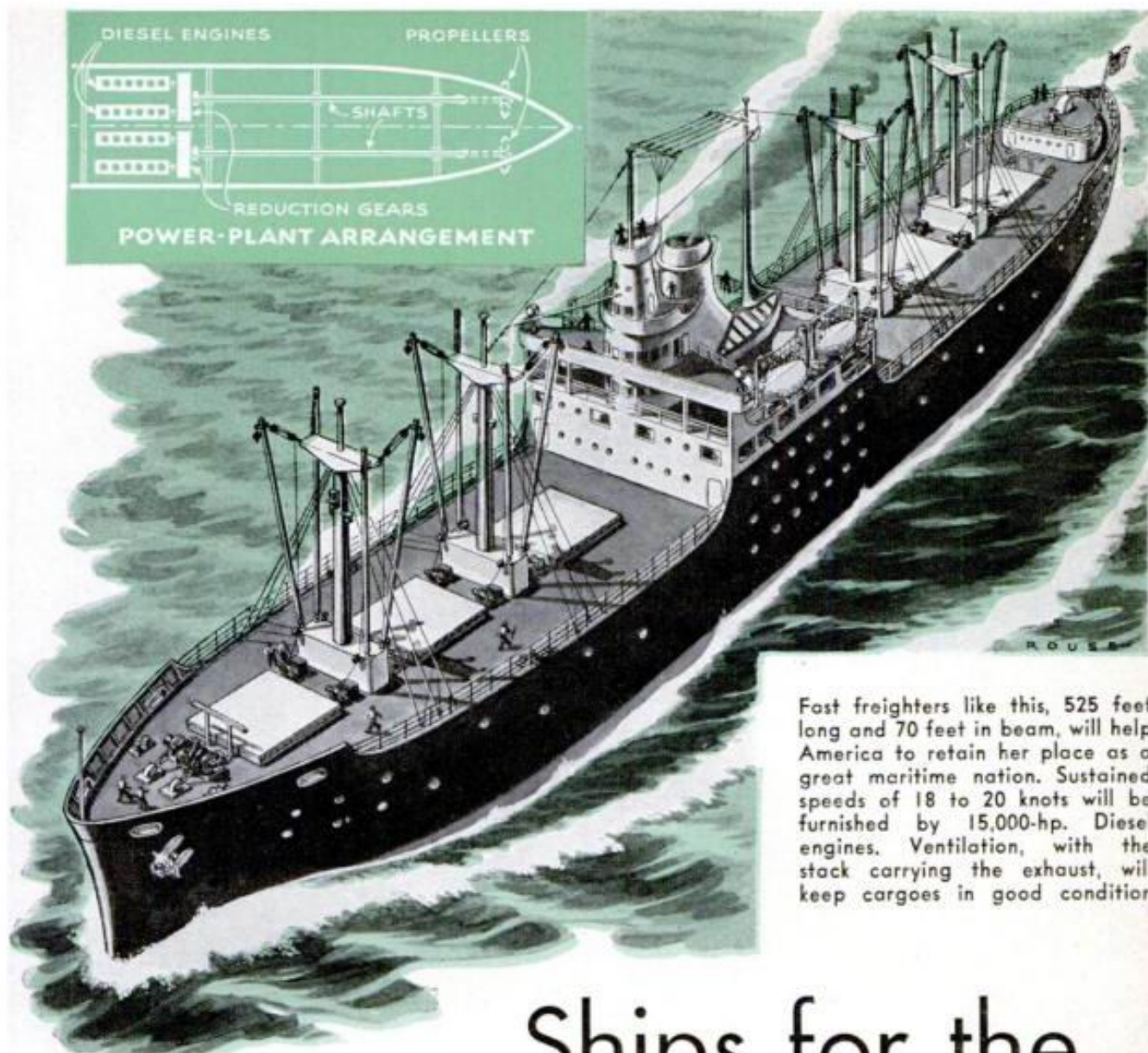
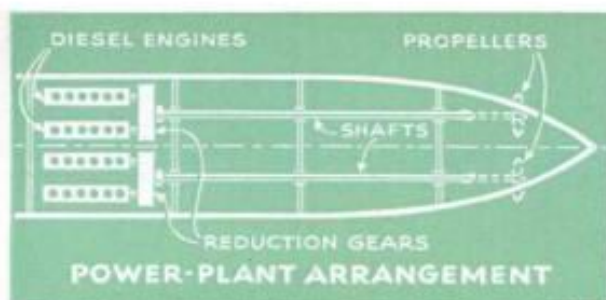




Rollers Give Landing Boat High Speed

A HIGH-SPEED, air-propeller-driven boat that literally rolls over the waves has been proposed by Pietro C. Lombardini, of England. In starting, the boat moves through the water on its hull, but once it attains 50 knots, a series of free-turning rollers, lowered into the water in place of

the hull, reduces the boat's resistance and enables it to increase its speed greatly. The drawing shows an adaptation for beach landings. As a small aircraft carrier, the fast ship would make it possible for planes to take off with a minimum run and to land at high speeds, the inventor claims.



Fast freighters like this, 525 feet long and 70 feet in beam, will help America to retain her place as a great maritime nation. Sustained speeds of 18 to 20 knots will be furnished by 15,000-hp. Diesel engines. Ventilation, with the stack carrying the exhaust, will keep cargoes in good condition

Ships for the Seas of Peace

By CAPT. W. MACK ANGAS (C.E.C.) U.S.N.

Drawings by STEWART ROUSE

Opinions expressed in the following article are the author's. They should not be interpreted as those of any branch or department of the Government.

ALONG with being the leading industrial power at the close of the war, the United States will also be a great maritime nation. With a fleet of medium-sized cargo vessels, tankers, and cabin liners as fine as or finer than any others afloat, our early postwar merchant fleet will lack only express superliners and will be fitted to carry its share of trade in the first days of peace.

To remain a great maritime nation, however, we must be prepared to construct improved vessels when science and industry return to normal. At that time materials and techniques that have been devoted to the war will enable shipbuilders to turn out vessels far surpassing those now in existence.

The most spectacular and highly publi-

cized merchant ships are the express superliners, and if transocean planes do not take too much of their trade, larger and faster ones will be built. Those operated before the war were of over 50,000 tons. Their speed, averaging 28 knots on a crossing, made it possible to maintain weekly service between New York and Europe with two ships.

Postwar superliners will be still faster, but probably will not exceed 32 or 33 knots, although it is estimated that 35 knots could

be used advantageously to allow longer periods for victualing, fueling, and cleaning ship. Over-all length will be kept to 1,100 feet and beam to 120 feet by channel, terminal, and docking limitations.

Propulsion will almost undoubtedly be by quadruple screws driven by geared turbines. Pressures as high as 1,200 pounds are likely, and steam temperatures may be raised by superheating to as much as 900 degrees Fahrenheit. Also possible are geared Diesel engines, Diesel-electric drive, and the recently developed mercury-steam turbo-electric system.

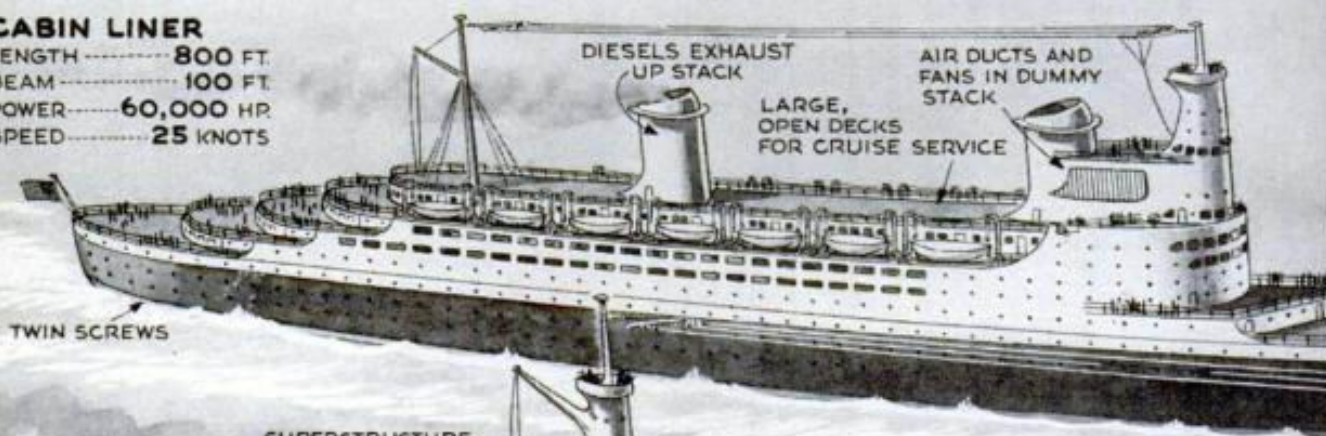
Cabin liners will suffer much less from air competition. Larger and more comfortable than even the finest of the prewar ships of this type, they will probably have a length

of 800 feet or more, with docking facilities in many of the cruise ports visited in the "off season" of the North Atlantic service. The power plant needed for their maximum speed of 24 or 25 knots will perhaps not exceed 60,000 or 70,000 horsepower, and their normal sea speed of 21 or 22 knots will be sustained with considerably less. For this, geared Diesel engines and Diesel-electric drive are much more probable than for the huge power outputs required for a superliner capable of over 30 knots.

By far the most important merchant ships are freighters. The finest yet produced are possibly the handsome and able C-3 ships of the United States Maritime Commission, and new ones will be in all likelihood a development of this type. World-

CABIN LINER

LENGTH 800 FT.
BEAM 100 FT.
POWER 60,000 HP
SPEED 25 KNOTS



SUPERSTRUCTURE OF SHOT-WELDED STAINLESS STEEL

ALL LIFEBOATS HAVE DIESEL ENGINES AND RADIOS

AFTER BOILER-ROOM STACK

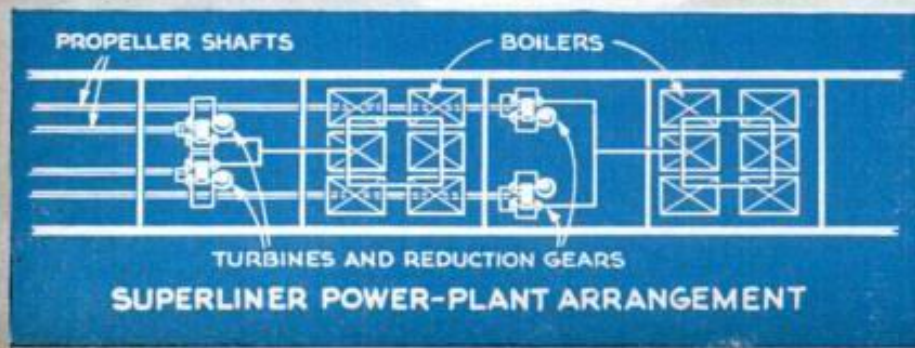
FORWARD BOILER-ROOM STACK

QUADRUPLE SCREWS UNDER STERN

SUPERLINER

LENGTH 1,100 FT.
BEAM 120 FT.
POWER 250,000 HP
SPEED 33 KNOTS

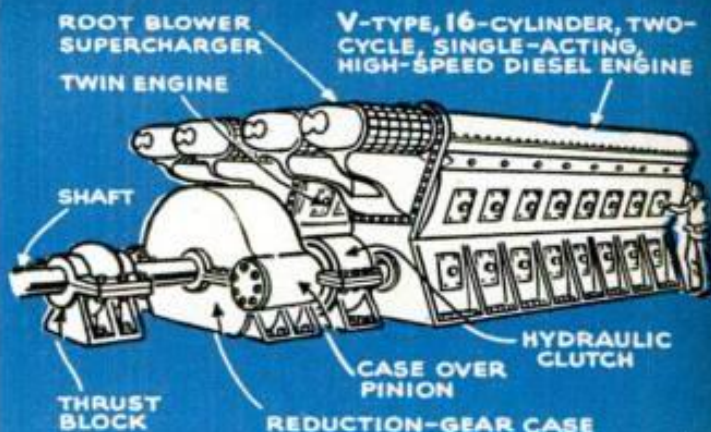
SHATTERPROOF GLASS WINDOWS



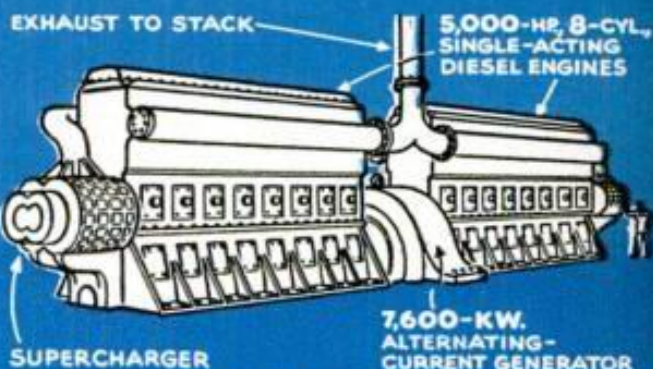
wide war improvements to channel, harbor, terminal, and docking facilities will permit lengths of 500 or even 525 feet. Sustained speeds as high as 18 or 20 knots may be expected.

Geared Diesel engines of about 15,000 total horsepower driving twin screws will probably propel the majority of these freighters, though undoubtedly some will employ high-pressure steam plants, and the internal-combustion, or "gas," turbine in conjunction with electric transmission is a possibility. It is also likely that the slightly higher efficiency of the single screw in ships of moderate size may lead to its utilization in services where the greater reliability and shallower draft made possible by twin screws are not necessary.

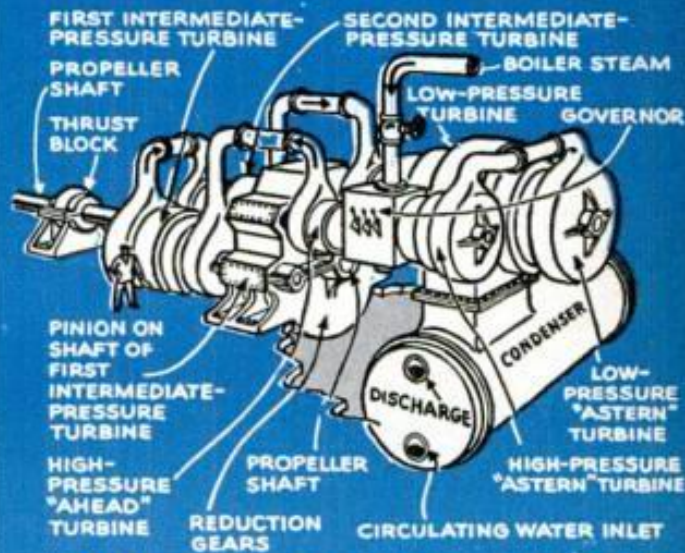
POWER-PLANT UNITS



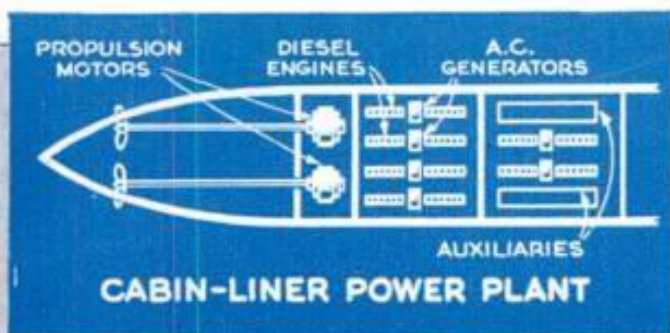
ONE OF THE TWO POWER UNITS, TWIN-SCREW FREIGHTER



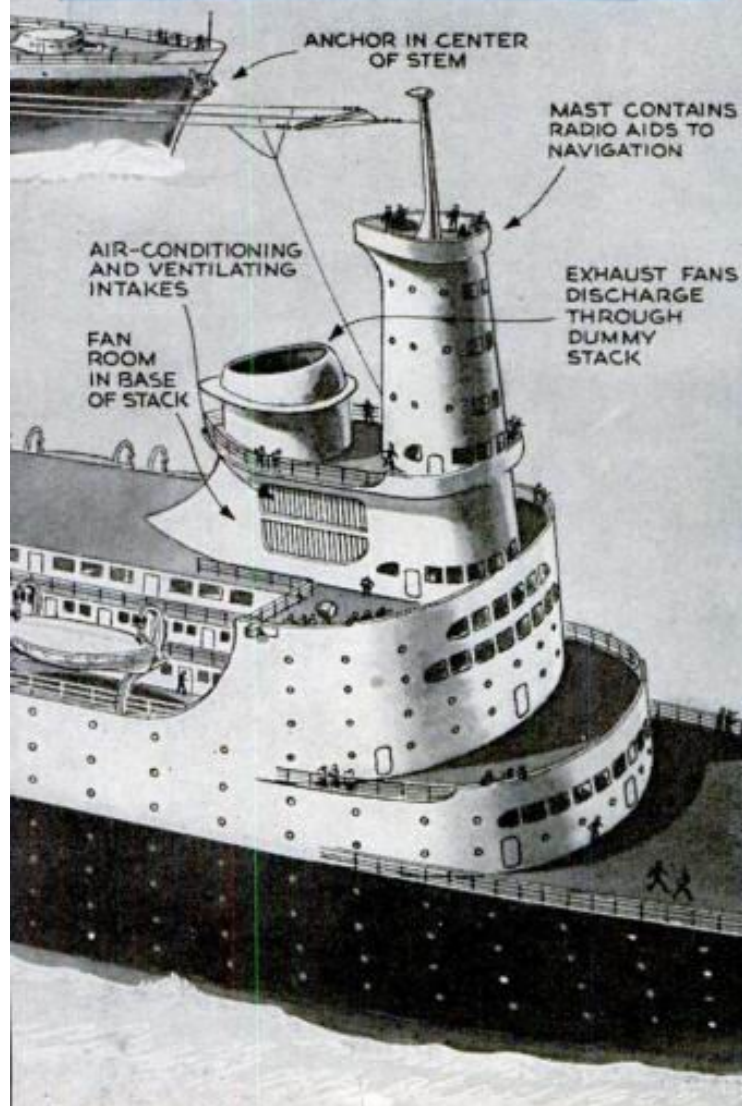
ONE 10,000-HP POWER UNIT, DIESEL-ELECTRIC CABIN LINER



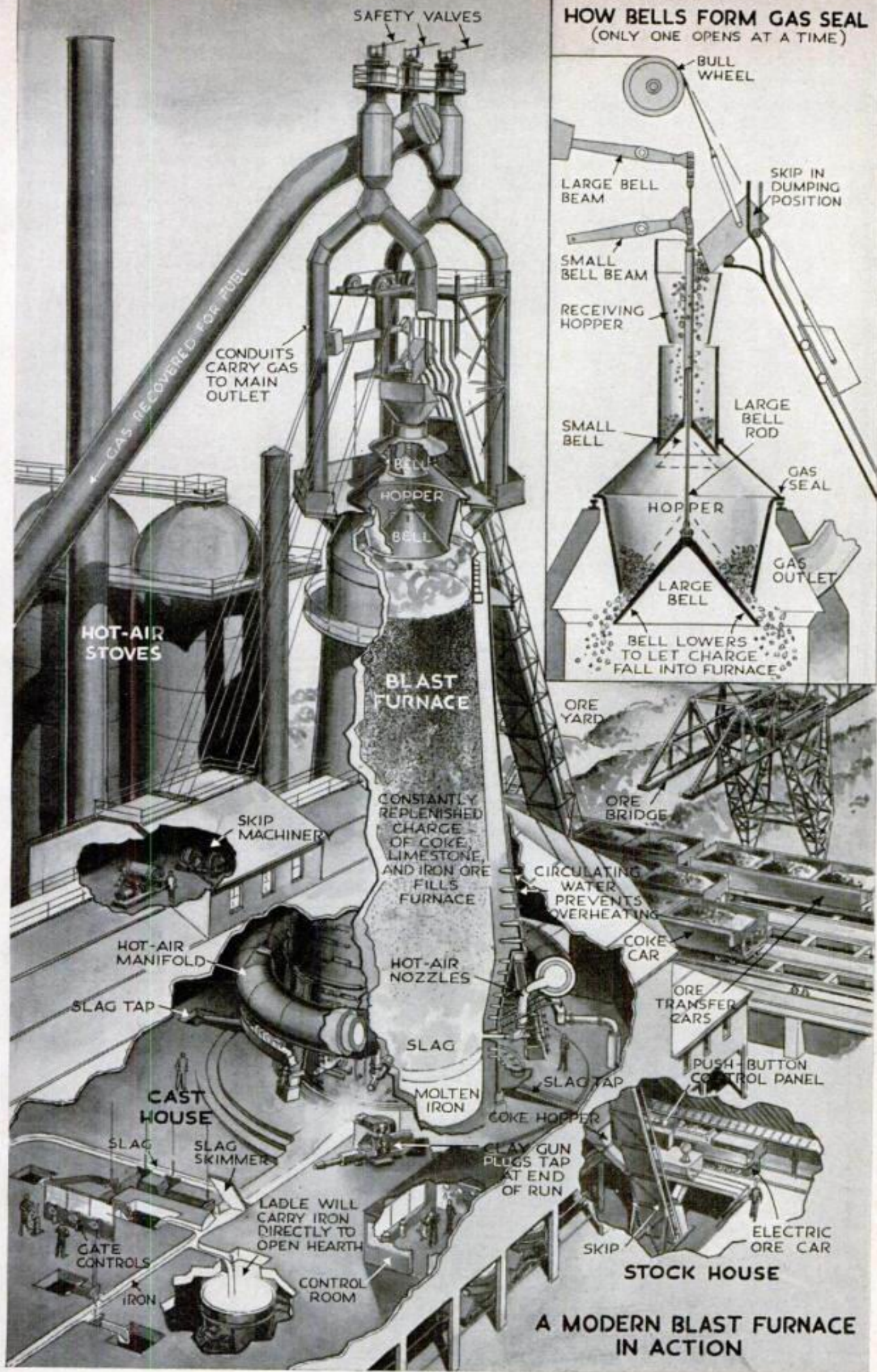
QUADRUPLE-EXPANSION SINGLE-REDUCTION-GEARED TURBINE UNIT. FOR SUPERLINER



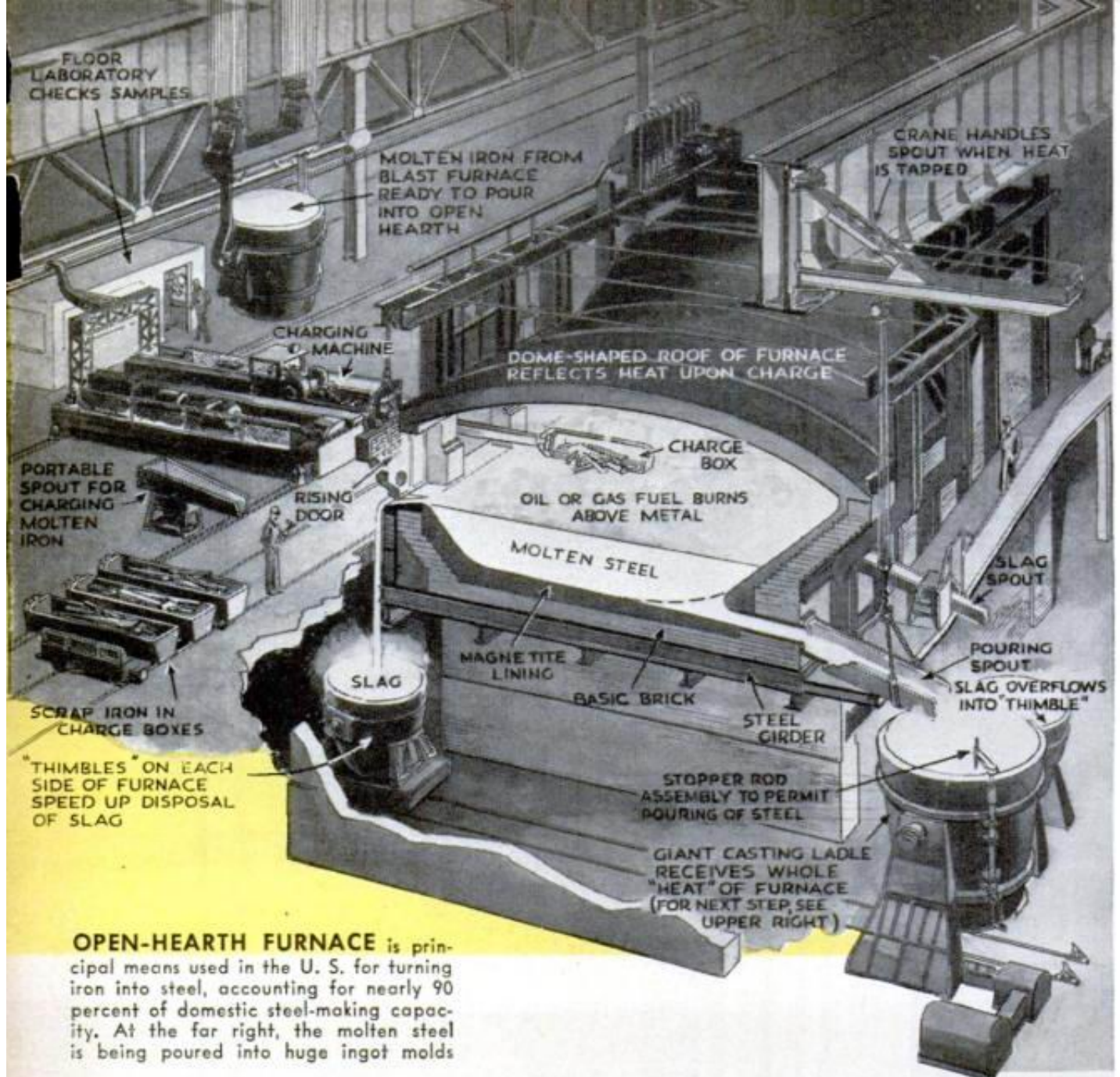
CABIN-LINER POWER PLANT



ANCHOR IN CENTER OF STEM



A MODERN BLAST FURNACE IN ACTION



OPEN-HEARTH FURNACE is principal means used in the U. S. for turning iron into steel, accounting for nearly 90 percent of domestic steel-making capacity. At the far right, the molten steel is being poured into huge ingot molds

trodes toward the charge with the aid of a small crane. When the electrodes barely touch the charge, electric arcs leap between them and the metal. The operator builds up the power to full voltage. Melting spreads from scattered puddles until the whole mass becomes liquid. Distribution of heat is believed to be aided by a curious electrical phenomenon, circulation of the metal in response to the heavy current passing through it.

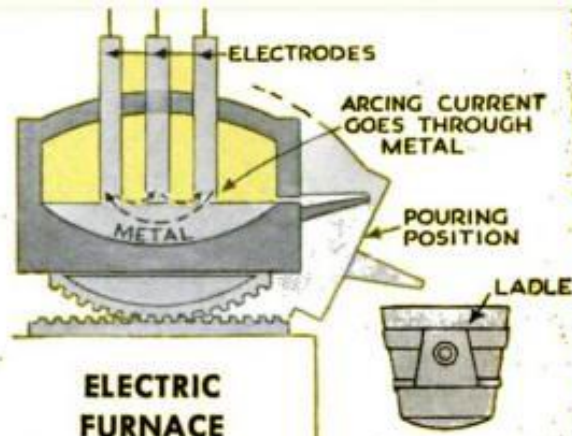
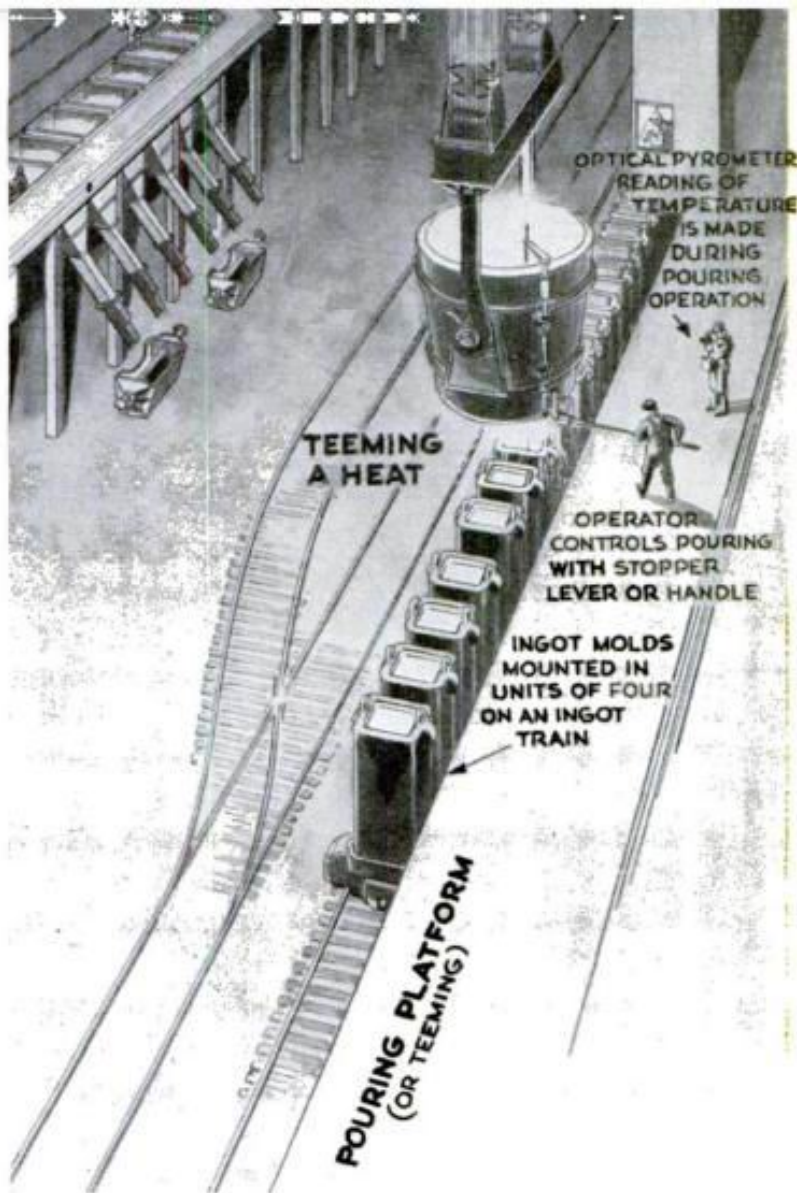
Frequent sampling calls for adding small amounts of various materials, until the composition is just right and the steel is ready to tap. Then, unseen machinery tilts the furnace and its whole surrounding platform. Metal pours from the tap hole into a waiting ladle, which transfers it to the ingot molds. A typical ingot of electric steel weighs seven tons.

Now the ingot, by whichever process produced, goes to a soaking pit. Here blast-

furnace gas reheats it to incandescence for passage through the many rolling mills that will reduce it to its final shape.

Two blasts from a signal horn. The slabbing mill is calling for metal. Over comes a glowing ingot to buck in vain against the mighty rolls—to be flattened between them and passed along, bumpety-bump, to other rolls that thin it again and again. Eventually it may end as coiled strip for manufacturing food cans. If the ingot's first stop was the blooming mill, it would take on a nearly square cross section, from being turned on its side between passages through the rolls. It might finally turn out as wire.

Where the home front is concerned, steel production is a major event on the war program. Industrial heads have been put together to scheme new ways for expanding the capacity of the steel mills, and it is possible that the output, at present 91,000,000



ELECTRIC FURNACE

Makes finest alloy steels in comparatively small heats. One of many types



BESSEMER CONVERTER

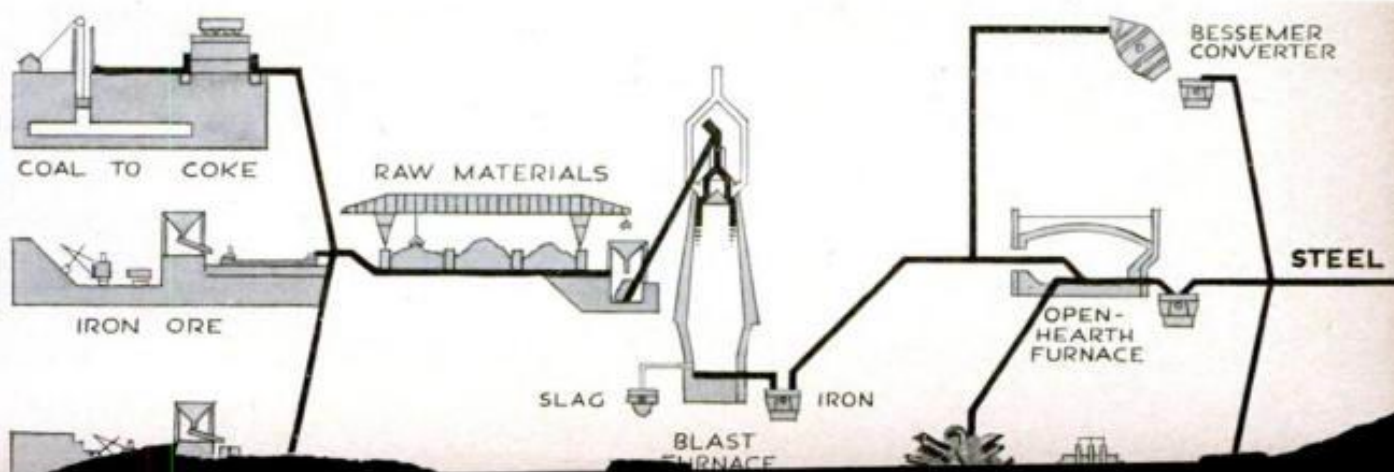
Most spectacular steel-maker, it blows air through the molten iron

tons a year, may in the next six months reach the staggering total of 96,000,000. Considering the daily requirements of steel tonnage, this goal is neither extravagant nor surprising. Every 24 hours the nation's war effort calls for enough steel to build and equip two giant battleships and more than 1,000 four-motor

bombers such as the Liberator and Fortress.

Four more signal blasts. "Faster!" There's a war to be won—and who knows it better than the men in the miles of steel plants that light up the Monongahela River by night? "Victory Valley," they call it, and with reason.

THESE ARE THE STEPS IN THE PRODUCTION OF STEEL



Are Big Cities "Ugly Monsters?"

Slum clearance is powerless to stop decay at the core of a city, says a famous architect. Since the trouble is obsolete city design, the answer may be to rebuild from the ground up.



By **FRANK ROWSOME, Jr.**
Drawings by **TED KAUTZKY**

MOST large cities are rotten to the core, according to Dr. Martin Wagner, a distinguished German architect who was, before Hitler, a city planner for Berlin, Hamburg, and Wilhelmshaven. Now a professor at Harvard, he describes modern cities as "mammoth monsters of ugliness, inefficiency, and distortion."

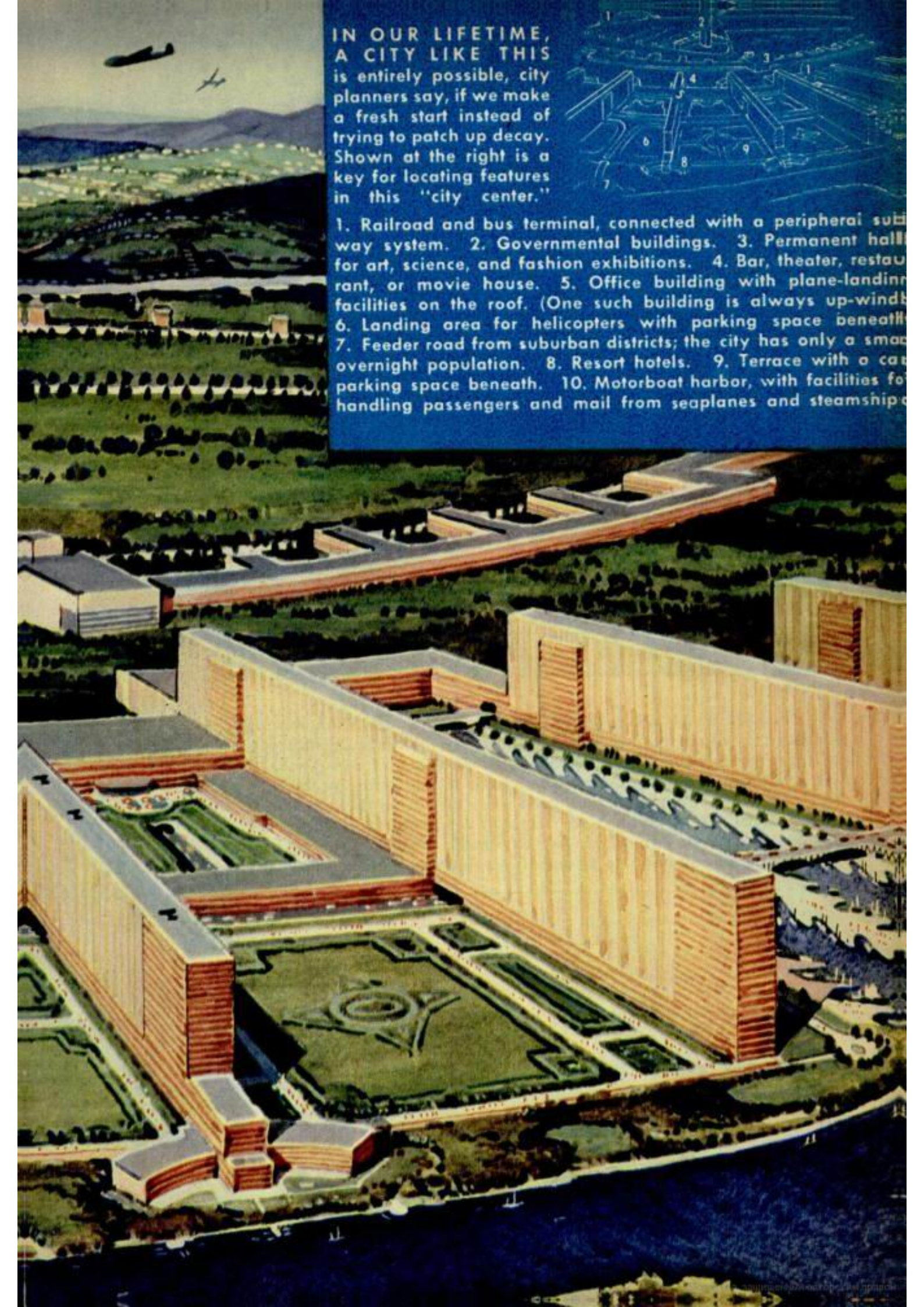
Slum clearance, to his mind, is about as hopeless as trying to stem a tide with a teacup. The root of the difficulty lies in archaic city patterns, which were usually influenced by such factors as horse-drawn traffic, water power, and wood or stone as structural materials. Patching up a present-day city, Dr. Wagner feels, is like trying to

change a stagecoach into a plane by repairing its decayed parts.

A city built from the ground up today might be a breath-taking metropolis—Buck-Rogers-like in effect and yet within reach in details. On pages 104 and 105 is a drawing that shows Dr. Wagner's ideas of a city created specifically for modern living.

Only a small percentage of the daytime population lives in the city itself. Most citizens live in small, country communities, and reach the city by high-speed train, express highway, or private helicopter. No manufacturing is done within the city, since industry is dispersed, near its raw materials and power. The city is entirely a center where people gather to do business, purchase goods, and go to schools or hospitals, movies or [\(Continued on page 106\)](#)





IN OUR LIFETIME,
A CITY LIKE THIS
is entirely possible, city
planners say, if we make
a fresh start instead of
trying to patch up decay.
Shown at the right is a
key for locating features
in this "city center."



1. Railroad and bus terminal, connected with a peripheral sub-
way system. 2. Governmental buildings. 3. Permanent hall
for art, science, and fashion exhibitions. 4. Bar, theater, restau-
rant, or movie house. 5. Office building with plane-land-
ing facilities on the roof. (One such building is always up-wind b-
6. Landing area for helicopters with parking space beneath
7. Feeder road from suburban districts; the city has only a small
overnight population. 8. Resort hotels. 9. Terrace with a car
parking space beneath. 10. Motorboat harbor, with facilities for
handling passengers and mail from seaplanes and steamships.

Sea-Floor Rover— Master of All Trades Underwater

BY HERBERT SHULDINER

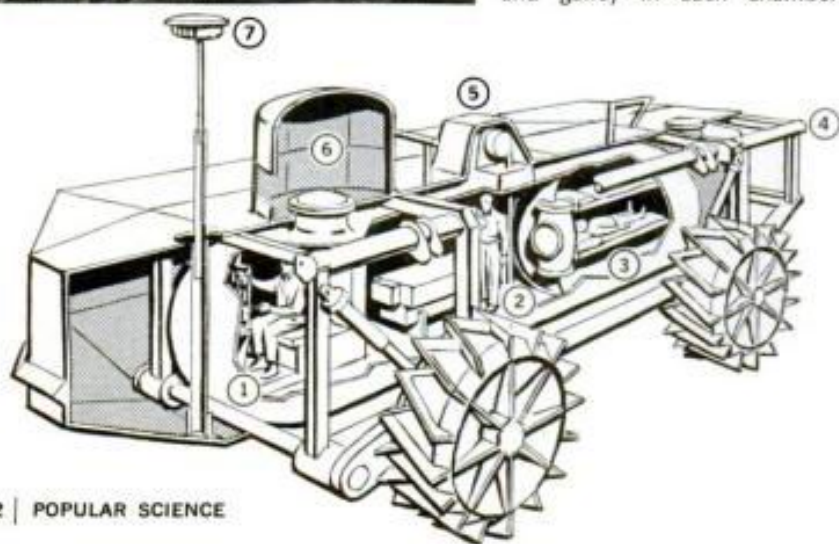
A giant undersea tractor that can roam the ocean floor at depths as great as 600 feet is about to provide a new dimension in oceanographic exploration. This sea-floor rover—called the Sea Bed Vehicle, or SBV, by its builders, Cammel Laird Ltd. of Birkenhead, England—is slated to undergo its first sea trials in December. It can ride over the soft, uneven ocean floor on its four huge wheels, giving aquanauts the kind of support and freedom they've never had before, for jobs like ocean-floor drilling, cable laying, mining, or as a base for diving over extended periods. Unlike free-swimming, deep-diving vehicles, the SBV is lowered by a support ship at the end of a cable which also supplies the umbilical links to the mother ship for power and communication.

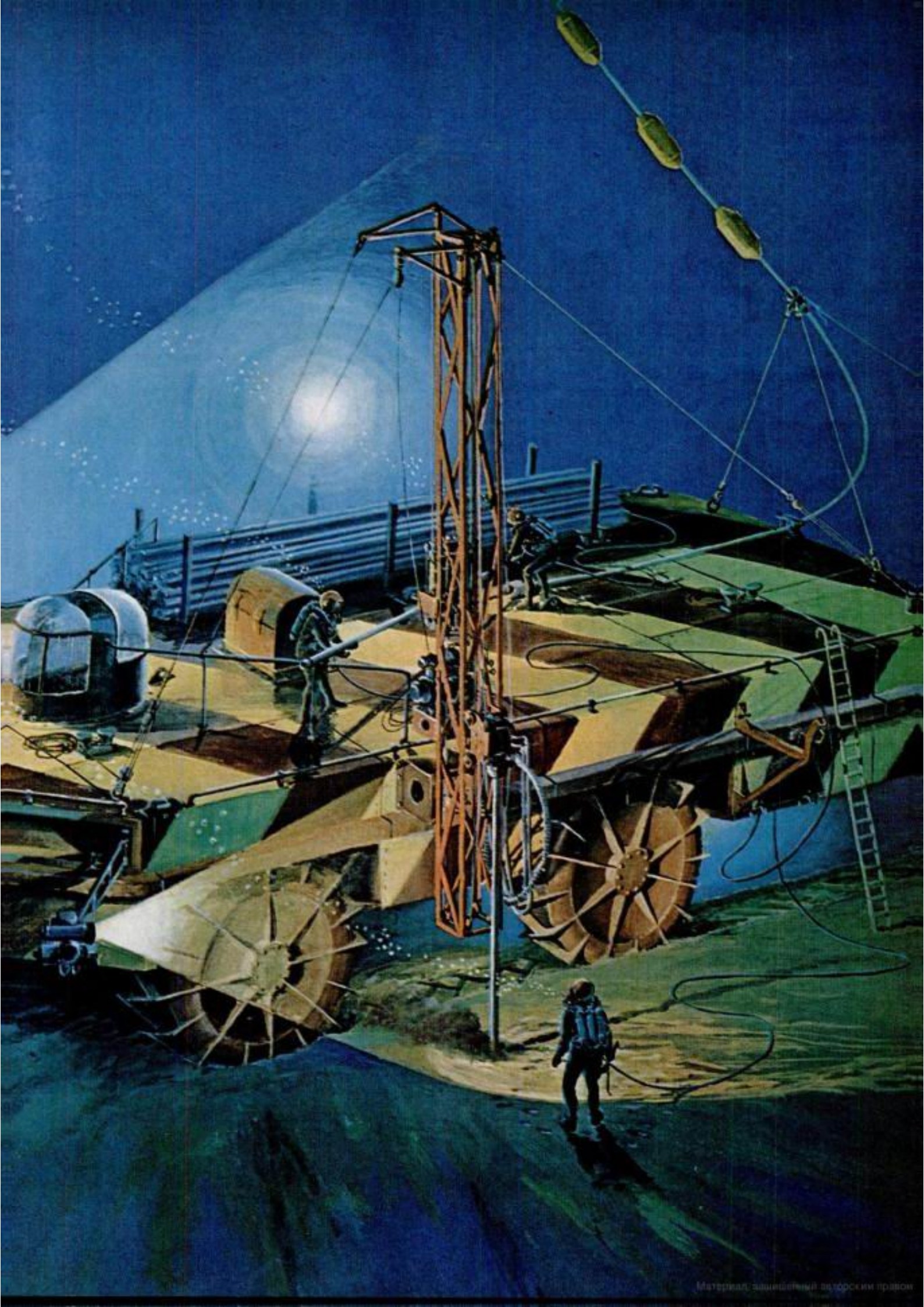
Once this 60-ton vehicle reaches the ocean floor, however, it is self-powered, with a direct-drive motor in each wheel. A dead-reckoning navigation system, two TV cameras, and a high-resolution sonar help the operator guide the rover. It can carry two persons in the control cabin, plus three divers, and support them for five days before resurfacing. Top speed? One-and-a-half knots.



Salvaging a wrecked ship (left) will be one of the jobs aquanauts will handle from the Sea Bed Vehicle. Undersea rover will be tested at end of this year

Inside look at the Sea Bed Vehicle below shows: (1) control room; (2) isobaric chamber; (3) hyperbaric chamber; (4) exterior frame; (5) winch housing; (6) free flooding observation cockpit; (7) sonar. The rover is 19 feet wide, stands slightly over 16 feet high with wheels extended for ocean-floor travel. The wheels are eight feet tall, three feet wide. Payload is 9,000 pounds. Afloat, it has a seven-foot draft, 101,000-pound displacement. There's a toilet and galley in each chamber





[NATURAL DISASTERS] CONTINUED

Another concept involves a squadron of cargo planes airdropping thousands of tons of a water-absorbing powder onto a hurricane to extract moisture from rain clouds. Dyn-O-Mat in Jupiter, Florida, manufactures superabsorbent products, such as garage mats designed to soak up oil from leaky cars. The firm is developing a gel that has shown promise in early trials. In July 2001, Dyn-O-Mat engineers dumped 8,000 pounds of their Dyn-O-Gel (an amount capable of absorbing 4,000 tons of water) over a small thunderstorm near the Florida coast. Within minutes, the storm disappeared from Doppler weather radar.

In a hurricane, the result would be two-fold. First, as the clouds dried out, the storm would wither. Then, as super-chilled Dyn-O-Gel droplets fell into the ocean beneath a storm, they would further weaken it by cooling the warm water that fuels its growth.

Dyn-O-Mat's founder and CEO, Peter Cordani, has already arranged to lease a specially rigged 747 "supertanker" to conduct trials on actual hurricanes. Meanwhile he has assembled an all-star team of scientists from labs at Florida State University, the National Center for Atmospheric Research, NOAA and elsewhere to begin running computer models that

Are hurricanes simply too big and powerful to respond to human-scale tinkering?

analyze the gel's effect on larger storms. "We already know the gel works," says Cordani, who lost his home during Hurricane Frances. "Now we need to figure out how much to use and where to put it."

Many scientists are skeptical, however. Chris Landsea, a hurricane expert with NOAA, wonders whether hurricanes are simply too big and powerful to respond to human-scale tinkering. "Thunderstorm activity alone could be equivalent to 200 times global electricity production," he points out. "It's just not physically feasible to make an impact." —MICHAEL BEHAR

[SPACE]

The Mini Shuttle

Russia partners with Europe to build its own reusable spacecraft for flights to the International Space Station and beyond.

WITH NASA'S BELEAGUERED shuttle still grounded over safety concerns—and given the unanswered questions about its replacement, the Crew Exploration Vehicle, which won't be ready to fly until 2012—the European Space Agency is mulling an option to buy its own ride to space. This month ESA plans to request \$60 million from its member states to help Russia prepare its new, reusable spaceship, the Clipper, for a crewless test flight by 2011 and a manned flight by 2012.

The six-person Clipper is designed to replace Russia's three-person Soyuz capsule, which has been in operation since the 1960s and is currently the only reliable transport to the International Space Station. Lighter than NASA's shuttle and more powerful than the Soyuz, the Clipper will be more than just a taxi to the ISS. Notes ESA official Manuel Valls, "It could go to the moon."

The Russian Federal Space Agency showed off a full-scale mock-up of the craft at the Moscow International Air Show in August. If all goes well—that is, if ESA ponies up funding—design studies of the Clipper could begin in early 2006. —DANIEL CLERY

GETTING INTO SPACE

The 13-ton Clipper is nearly twice the weight of the Soyuz capsule and thus requires a stronger launcher. Russian engineers are considering several options, including the Ukrainian-built Zenit and a yet-to-be-developed Russian rocket called the Onega [pictured here], which is essentially a beefed-up version of the Soyuz launcher.



CREW CABIN

The 21-foot-long passenger cabin and reentry vehicle will accommodate six crew members (two pilots and four other astronauts or tourists), plus 1,100 pounds of cargo—more than 10 times that of the Soyuz.

LIVING ROOM

The 13-foot-long detachable habitation module contains life-support systems, including a toilet, as well as the docking port for the International Space Station.

POWER THRUSTERS

The instrument module houses thrusters to separate the Clipper from its launcher and to maneuver the spacecraft. It also contains the electrical system, which is powered by extendable solar arrays. Both the instrument module and the habitation module are jettisoned before reentry.

HEAT SHIELD

The craft's exterior consists of heat-resistant ceramic panels designed to endure several flights before requiring replacement.

TWO LANDING OPTIONS

The craft's stubby wings enable the pilot to steer during the descent and make a controlled landing on an airport runway. In case of an emergency, parachutes ensure that the Clipper can land safely on the plains of central Russia.





I was an 18-foot robot

Strapped in place, the author was the steel giant's brain. His motions were duplicated by the robot, but with enormous power

By James R. Berry

MY FIRST TASK was to learn how to balance. Confidently, perched in the body of an 18-foot, two legged robot, I leaned forward. The platform I was standing on, sensitive to my slightest shift of weight, moved too. With a loud sigh of hydraulic valves the automaton I was commanding sprang to life.

Instantly, it mimicked my move. Before

I realized what had happened, it pitched forward out of control. Using my toes for leverage, I frantically tried to stop our headlong plunge by throwing myself backwards. The robot's reaction was as quick as it was violent. Accompanied by a piercing shriek of valves, the automaton shuddered to a halt, then swiftly heaved back. Before I could react, it had crashed down on its heels with a jolt that rattled every bolt in its body.

Able to Rock

More warily now, I tried the maneuver again, this time successfully. After a few minutes of cautious trials, I was able to rock on my feet while the automaton, duplicating my moves, swung back and forth in slow, five-foot arcs. Soon, I could keep the machine where I wanted with a slight pressure of heel or toe.

Now, holding the robot in quivering equilibrium, I bent forward at the waist. The automaton's hips—controlled by a movable metal frame strapped to my back—moved and the machine dipped forward in a polite bow. I bent backwards and the

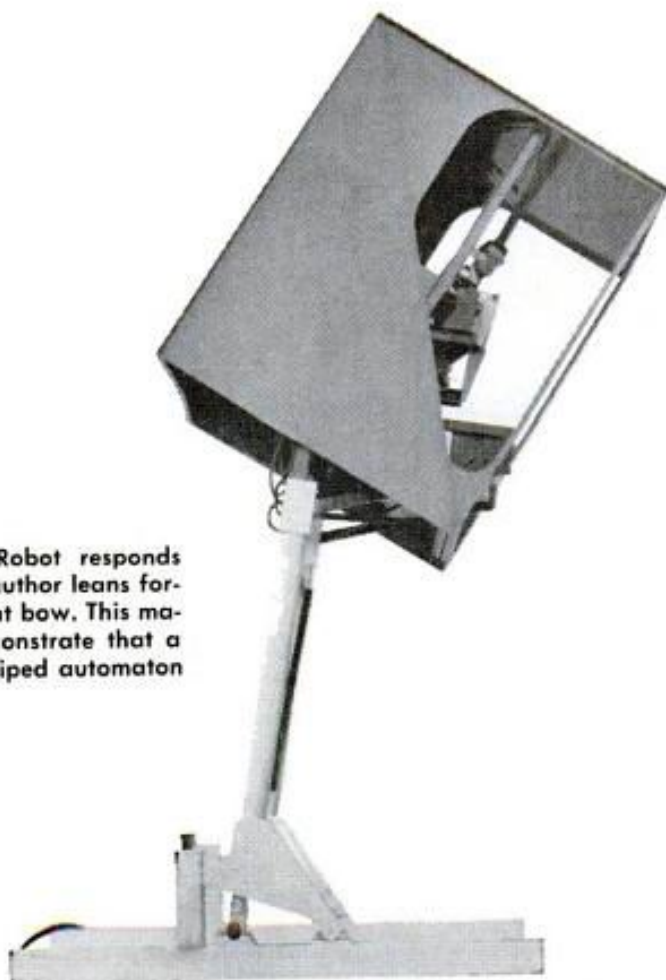
robot obediently did the same. Compared with balancing on my feet, this maneuver was a cinch. Inspired by my success, I raced through all the motions I had learned. The hydraulic system hissed, roared, and wailed as the automaton went through a series of movements as outlandish as the latest discotheque dance.

I was at General Electric's Advanced Technology Laboratories in Schenectady, N.Y., harnessed in the Pedipulator, one of an extraordinary new race of robots with the tongue twisting name of cybernetic anthropomorphic machines—CAMs, for short. This CAM, precursor of a generation of walking automatons, was built to demonstrate that a man can balance a bipod robot. Achieving balance is the first and most difficult part of walking. So, at the moment, the Pedipulator's feet are stationary and its arms, though developed, await being scaled up and bolted on.

What will the fully operating, walking robot actually be like? From the experience I'd just had and from what the GE engineers told me, I could easily imagine the robot at a building site or in a ship-



MONSTER COPYCAT. Robot responds immediately when the author leans forward and executes slight bow. This machine was built to demonstrate that a man could balance a biped automaton



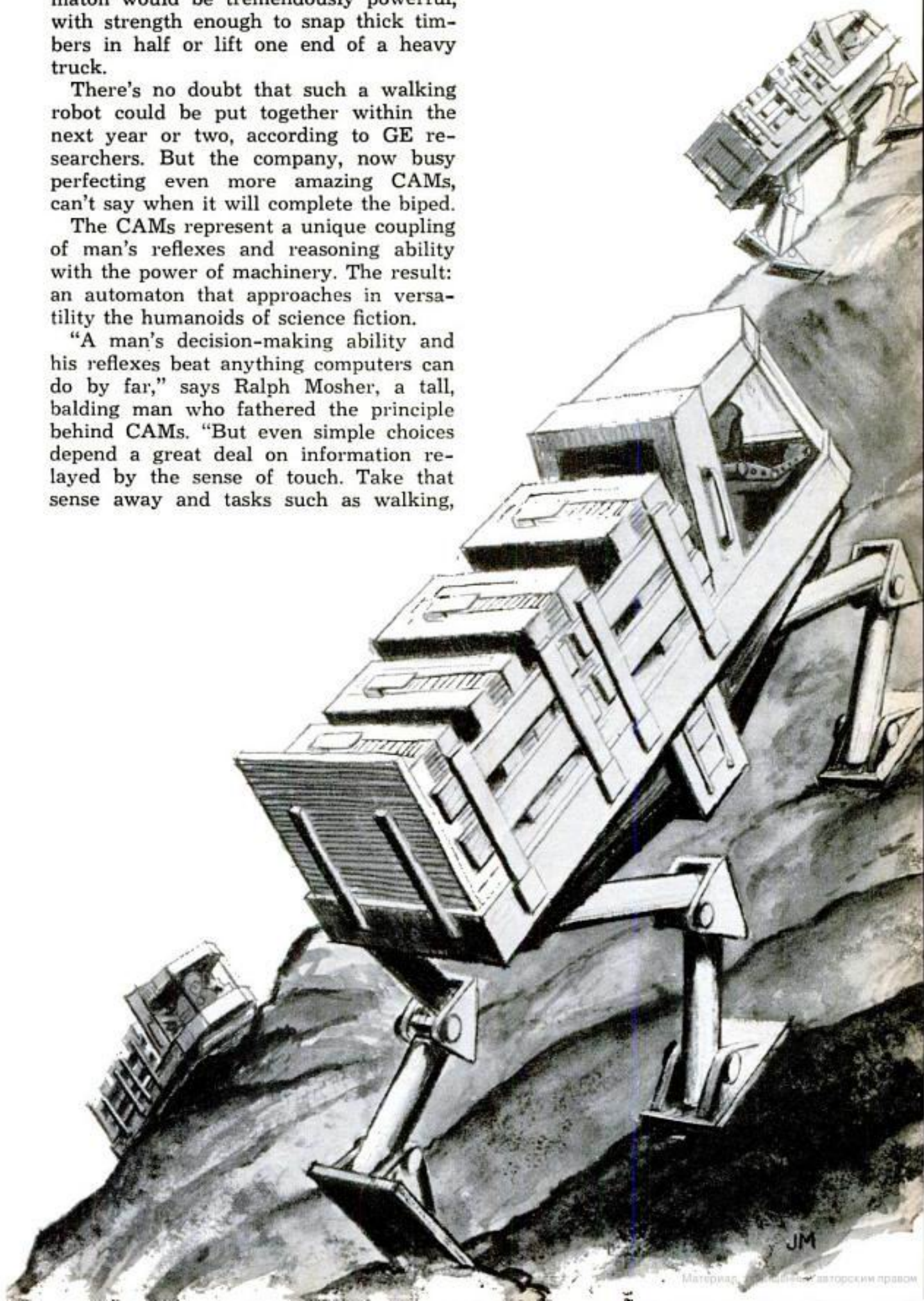
yard, clanging about on heavy steel feet, lifting bulky metal parts into place with its steel arms and making delicate adjustments with pincerlike hands. The automaton would be tremendously powerful, with strength enough to snap thick timbers in half or lift one end of a heavy truck.

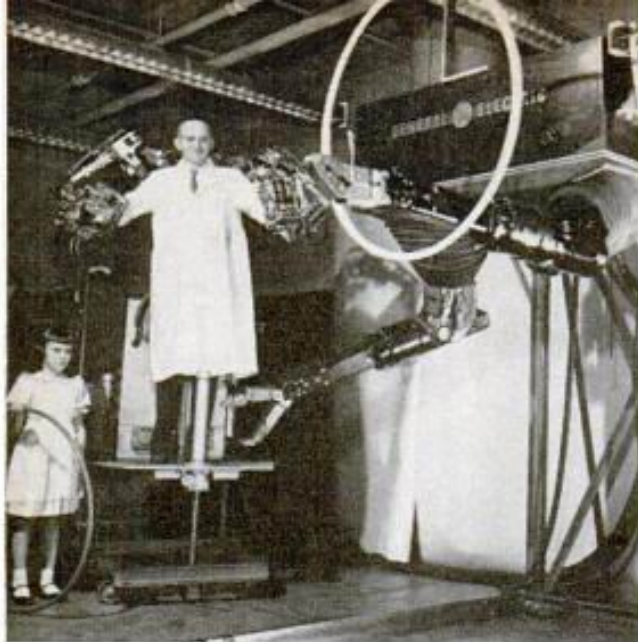
There's no doubt that such a walking robot could be put together within the next year or two, according to GE researchers. But the company, now busy perfecting even more amazing CAMs, can't say when it will complete the biped.

The CAMs represent a unique coupling of man's reflexes and reasoning ability with the power of machinery. The result: an automaton that approaches in versatility the humanoids of science fiction.

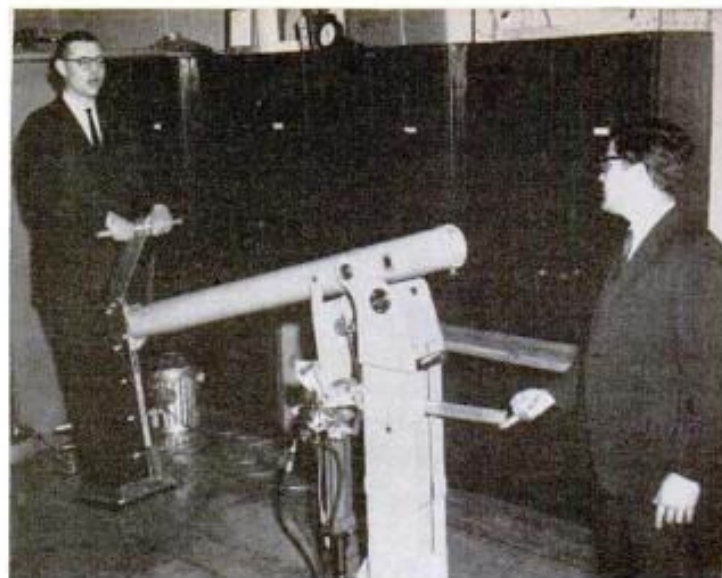
"A man's decision-making ability and his reflexes beat anything computers can do by far," says Ralph Mosher, a tall, balding man who fathered the principle behind CAMs. "But even simple choices depend a great deal on information relayed by the sense of touch. Take that sense away and tasks such as walking,

QUADRUPED ROBOTS, now under development for the Army, would be used primarily as cargo carriers in rough or marshy country, where even tanks bog down





INVENTOR RALPH MOSHER makes Handyman spin hoop. Machinery around Mosher's arms transmits every motion to the robot's arms and pincerlike hands



FINGER PRESSURE applied by author is enough to lift 150-pound man. This boom was used in the development of system for controlling robot's limbs

opening a door, or squeezing a tube of toothpaste become major problems."

CAMs incorporate a sense of touch. By a system called force feedback, the operator of a CAM feels the strains and stresses in the robot's limbs and body as though they were his own. The operator's arms, legs, and body are strapped into mobile, jointed frames called follower racks. Like an external skeleton, the follower racks pick up his every move, causing a corresponding, but amplified, motion in the CAM's analogous limbs and body.

But the follower racks serve another purpose. As the CAM does work, from balancing itself to carting boulders, its joints undergo stress. Part of this stress is hydraulically fed back to the follower racks, causing a proportionate strain in the operator's muscles. A simple adjustment increases or diminishes the amount of stress the operator feels.

Although CAMs haven't yet reached the stage of assembly-line production, they're already being eyed for scores of jobs that demand the reasoning power and dexterity of a man and the strength of a bulldozer. Some possible applications:

- Builders could use CAMs to lift steel girders into place, raise walls of prefabricated houses, tote materials around a construction site. CAMs with steamshovel-sized scoops replacing hands could dig tunnels, basements, or trenches, easily maneuvering where ordinary equipment couldn't be used. They would be especially helpful in archeological excavation where

their delicate sense of touch would be invaluable in uncovering ancient towns without damaging structures and artifacts.

- After disasters, CAMs could replace telephone poles, string cables, stack huge sandbags, and remove tons of wreckage at a throw. Others might simply wander through an emergency area on the lookout for survivors and remove them to safety.

- CAM artificial limbs might be linked to nerve centers and muscles in the stump of an amputee. The Woodrow Wilson Rehabilitation Center in Virginia is looking into just such a possibility. If successful, such limbs would pass a sense of feeling to remaining muscles, perhaps even to the nerves.

- Shipyards, auto and aircraft plants and other heavy manufacturing centers could use CAMs to assemble big but sensitive equipment. At piers, truckyards and rail terminals, CAMs could unload and load tons of cargo in a trip, putting it in place as easily as a child stacks blocks.

Improvements already envisioned would extend the range of the CAMs' usefulness even more. "There's no reason why the operator has to be inside his CAM," explains Mosher. "You could link the two by radio." Such a system, while probably at least a decade away from perfection, has incredible possibilities.

A remote-controlled CAM, for instance, could reconnoiter the ocean's floor, noting geological formations, locating mineral

(Please turn to page 202)

MAN AMPLIFIERS:

Superman suit is modeled by the author at Cornell Aeronautical Lab, Buffalo, N.Y. Joints will be powered to multiply the wearer's strength as structure follows his movements.



Machines That Let You Carry a Ton

Strap on the "exoskeleton" and your strength is multiplied many times over—you'll be able to handle a ton with all the flexibility of human muscle power

By WALLACE CLOUD/PS Science Editor

When they strapped me into the superman suit, I felt like Frankenstein's monster getting up off the operating table.

I clonked around the room like a gorilla, with this 35-pound jointed "exoskeleton" hanging onto me.

"Why are you bent over like that?" said Neil Mizen, the project engineer at Cornell Aeronautical Laboratory.

I straightened up and discovered that I could move freely, even though the exoskeleton didn't have quite as many joints as I

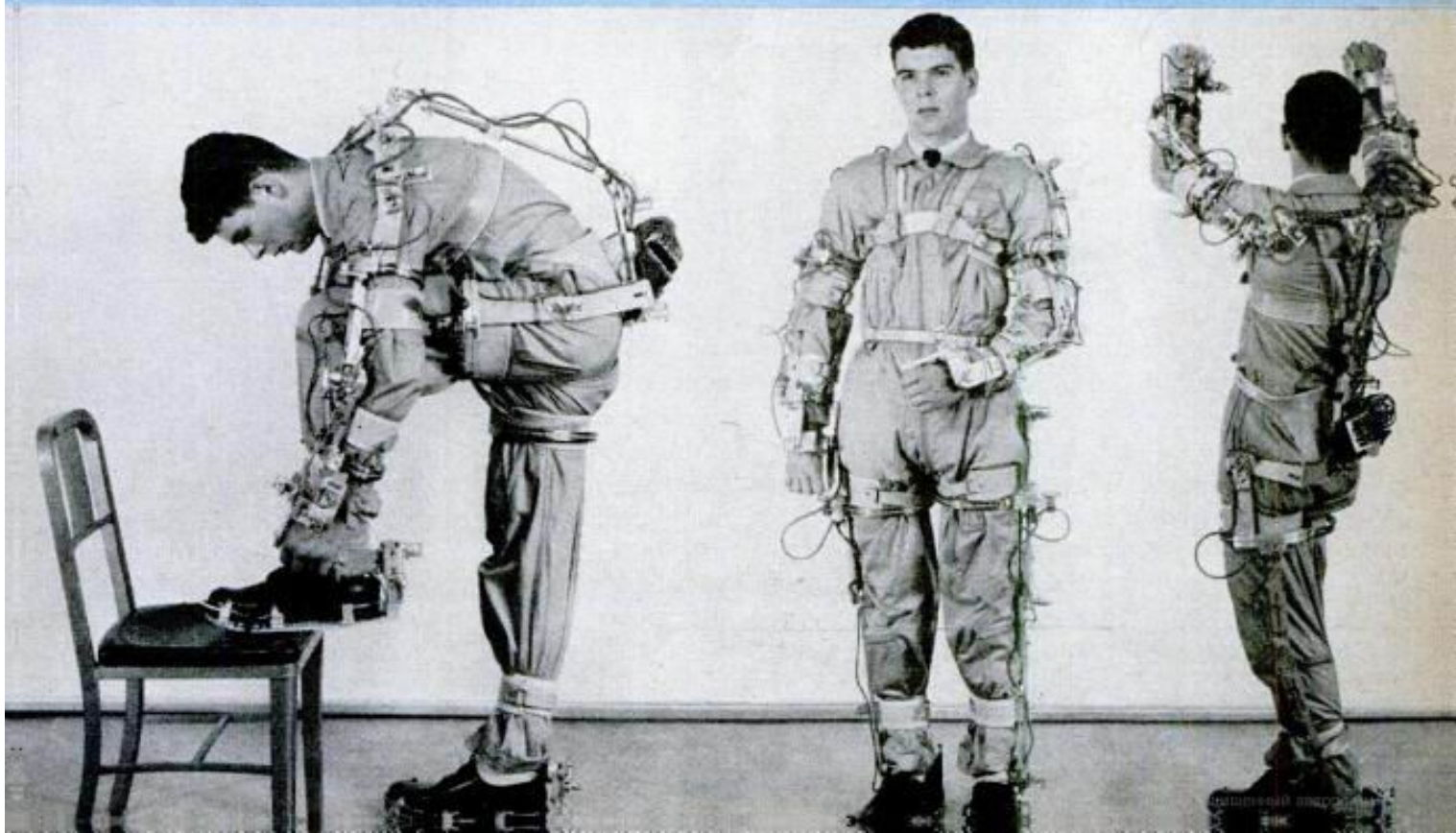
did. It wasn't up to some of the intricacies of the frug, but it followed me pretty closely.

The next step will be to put hydraulic motors at all the joints, and then it really will be a superman suit. Wearing it, any normal person will be able to heft 1,000 pounds—with each hand. You'll be able to carry a ton like a sack of groceries.

You'll have an 80-pound power pack on your back—a 20-horsepower gasoline engine plus fuel tank. But you won't be carrying it. The powered exoskeleton will be.

Continued

Flexibility of exoskeleton, wired to record motion, is shown by technician Ronald Patterson.





First uses of the exoskeleton are expected to be military. Here, a GI in a superman suit unloads munitions at a jungle helicopter landing field.



Superman-suited construction worker positions a heavy valve on site of a chemical plant—one of many civilian uses foreseen.

and it will also be supporting its own weight of about 400 pounds.

What a nutty idea, I thought when I first heard of it. But it turns out this is no joke. It's being developed for the Office of Naval Research.

The Navy wants the superman suit to help sailors manhandle torpedoes, bombs, and machinery in the cramped quarters aboard ship and in submarines. The exoskeleton could take the place of any number of hoists, overhead cranes, and other special-purpose weight-lifting equipment.

The Air Force and the Army are also interested. Exoskeletons would be useful for unloading and handling cargo and weapons in rugged terrain such as the jungles and rice paddies of Vietnam, and for construction work where a lot of specialized machinery is not available.

Multiplying muscle power. Cornell's exoskeleton is one of several "man-amplifier" projects underway in the U.S. Although there are differences, the basic idea is to put a man inside a machine that will duplicate his movements, but with greatly amplified strength and endurance.

One of these is the well-known "pedipulator," or walking machine, which GE has been developing for several years. This 18-foot-tall monster would walk on jointed legs, duplicating the movements of a man standing inside a cab at the "hips" of the

machine. GE is working on the legs now, planning to add powerful arms.

A number of laboratories are doing research on controlling such machinery with "myoelectric" signals—electric currents generated by the muscles. The signals can be detected by means of electrodes taped to the skin. This research is aimed largely at developing better artificial limbs for amputees, but myoelectric signals could provide fast, sensitive control of man amplifiers.

When production models of man amplifiers are available, it's unlikely that they will be limited to military use. In factories and construction work, man amplifiers, perhaps costing only a few thousand dollars, will be able to do more things than present materials-handling equipment. They will be able to operate without special installation or site preparation, and will also make it possible to move and manipulate heavy objects with delicacy and precision.

Some tricky problems remain to be solved. At Cornell, project engineer Mizen explained, the approach was to build an unpowered exoskeleton that would cling to a man, to see what kind of strength-increasing structure could be built, and how many joints it would need and how they would have to move. The one I tried on was the result.

It was built to the measurements of

[Continued on page 204]

military and civilian—are limited only by your imagination

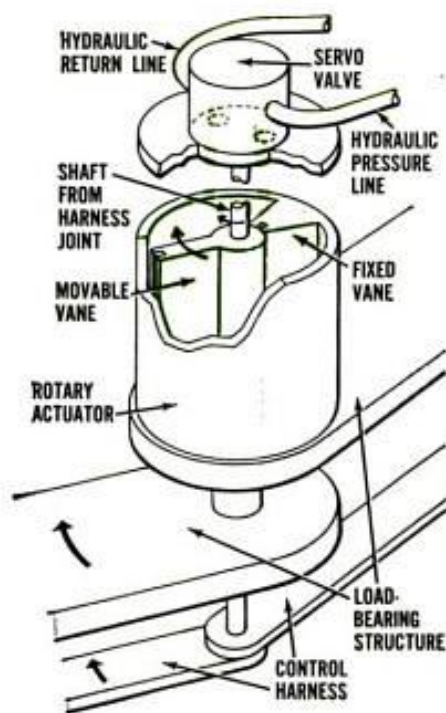


Exoskeleton can be made bigger or smaller than the man in the control harness. Here, a giant version replaces a derailed ore car at a mining site.



A miniature version, exposed to radioactivity, works to free jammed control rod of a nuclear reactor as operator watches on a TV monitor.

Next phase of development: applying power to the joints



Acid test of Cornell's exoskeleton design is whether power applied to the joints can be controlled precisely by the wearer. Mock-up shows sizes and locations of the hydraulic motors or actuators that will power the exoskeleton's arms and shoulders. This load-bearing structure will be linked to a harness like the unpowered exoskeleton shown on preceding pages. How each harness joint controls the corresponding joint of the structure is depicted in the diagram, an exploded view of the hydraulic actu-

ator and servo valve attached to the joint. Movement of the harness joint is transmitted by its shaft to the servo valve atop the actuator. The valve regulates the pressure of hydraulic fluid on each side of the movable vane in the actuator. Movement of the vane is conveyed by its shaft to the structural member, positioning the structure joint so it corresponds to the position of the harness joint. Some pressure is fed back through the valve, so the wearer knows the position of the structure.

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Popular Science

MONTHLY

Why Can't We Make Cars Safer?

By SEN. ROBERT F. KENNEDY

My Adventures on Wheels

By ERLE STANLEY GARDNER

COMPLETE PLANS:
A Lock-Up Workbench
That Protects Your Tools

FIRST '66 ROAD TESTS
Ford • Chevrolet • Plymouth
Falcon • Valiant
Chevy II • American

**10 Sure Ways to Improve
Your TV Picture**

Now It's Man Amplifiers:
MACHINES THAT LET
YOU CARRY A TON



FARMING IN THE SKY

Agriculture is broken. Traditional techniques use too much energy and produce too little food for our growing planet. One fix: skyscrapers filled with robotically tended hydroponic crops and lab-grown meat **BY CLIFF KUANG**

BY 2025, the world's population will swell from 6.6 billion to 8 billion people. Climate simulations predict sustained drought for the American Midwest and giant swathes of farmland in Africa and Asia. Is mathematician Thomas Malthus's 200-year-old prediction, that human growth will one day outpace agriculture, finally coming to pass? Advances in farming technology have kept us fed so far, but the planet's resources are tapped.

The choice is clear—rethink how we grow food, or starve. Environmental scientist Dickson Despommier of Columbia University and other scientists propose a radical solution: Transplant farms into city skyscrapers. These towers would use soil-free hydroponic farming to slash demand for energy (they'll be powered by a process that converts sewage into electricity) while producing more food. Farming skyward would also free up farmland for trees, which would help remove carbon dioxide from the atmosphere. Even better, vertical farms would grow food near where it would be eaten, thus cutting not only the cost but the emissions of transportation. If you include emissions from the oil burned to cultivate and ship crops and livestock in addition to, yes, methane from farm-animal flatulence, agriculture churns out nearly 14 percent of the world's greenhouse-gas emissions.

You can't buy vertically grown groceries just yet. Most urban farming efforts have been small-scale experiments run in neighborhood parks. Despommier's vision is bigger: a \$200-million, 30-story tower covering an entire city block, stuffed with enough fruit, vegetables and chickens to feed 50,000 people. "With waste in and food out, a vertical farm would be like a perpetual-motion machine that feeds a lot of people," he says. Most of the technology already exists, he adds, and with some refining, the project could be up and running quickly if granted 0.25 percent of the subsidies paid to American farmers in the past decade—a piddling \$500 million.

Despommier is advising investors in Abu Dhabi and South Korea who are considering vertical farms for new eco-cities. Seattle and Las Vegas are investigating similar, smaller concepts. Turn the page to explore the farm of the future, inspired by cutting-edge research from agricultural companies and scientists. With any luck, it will help repel the Malthusian catastrophe for another 200 years.



OPEN THE PAGE to see the vertical farm's high-tech inner workings. Robotic crop pickers! Lab-grown chicken! Glowing bacteria!

FROM THE GROUND UP

Farming in a skyscraper takes more than just a seed and some dirt. Here, your guide to the automated farming technologies, lab-grown meat, glowing bacteria, and sewage-to-electricity converters that will help vertical farming take off



A THE AQUAPONIC MERRY-GROW-ROUND

Vertical-axis wind turbines are potentially 50 percent more efficient in low wind conditions than conventional turbines.

Farmers load harvested plants onto a central elevator to be sold at the grocery store below.

ALTHOUGH HYDROPONICS and fish farms produce high yields, they're also high-maintenance. Soil-free hydroponic systems require frequent nutrient replenishment, and fish tanks need constant flushing of fouled water. But pair the two in one "aquaponic" system, and the flaws become virtues: The fish waste becomes plant fertilizer, while the plants clean the dirty water.

automated farming systems, takes aquaponics one step further. The tank's slow current carries floating trays of plants [1] past nutrient dispensers [2] and, by the end of the weeks-long trip, the plants are ready for harvest. Below them swim high-protein tilapia [3], whose ammonia-laden waste sinks to a gravel bed [4], where bacteria convert it to nitrogen.

Ceiling-mounted systems monitor and control humidity, temperature, and nutrient distribution.

The system pumps this nitrogen-rich water to the plants, which consume the nitrogen and return clean water to the fish.

This automated "conveyor belt" system, conceptualized by OrganiTech, an Israeli company that creates



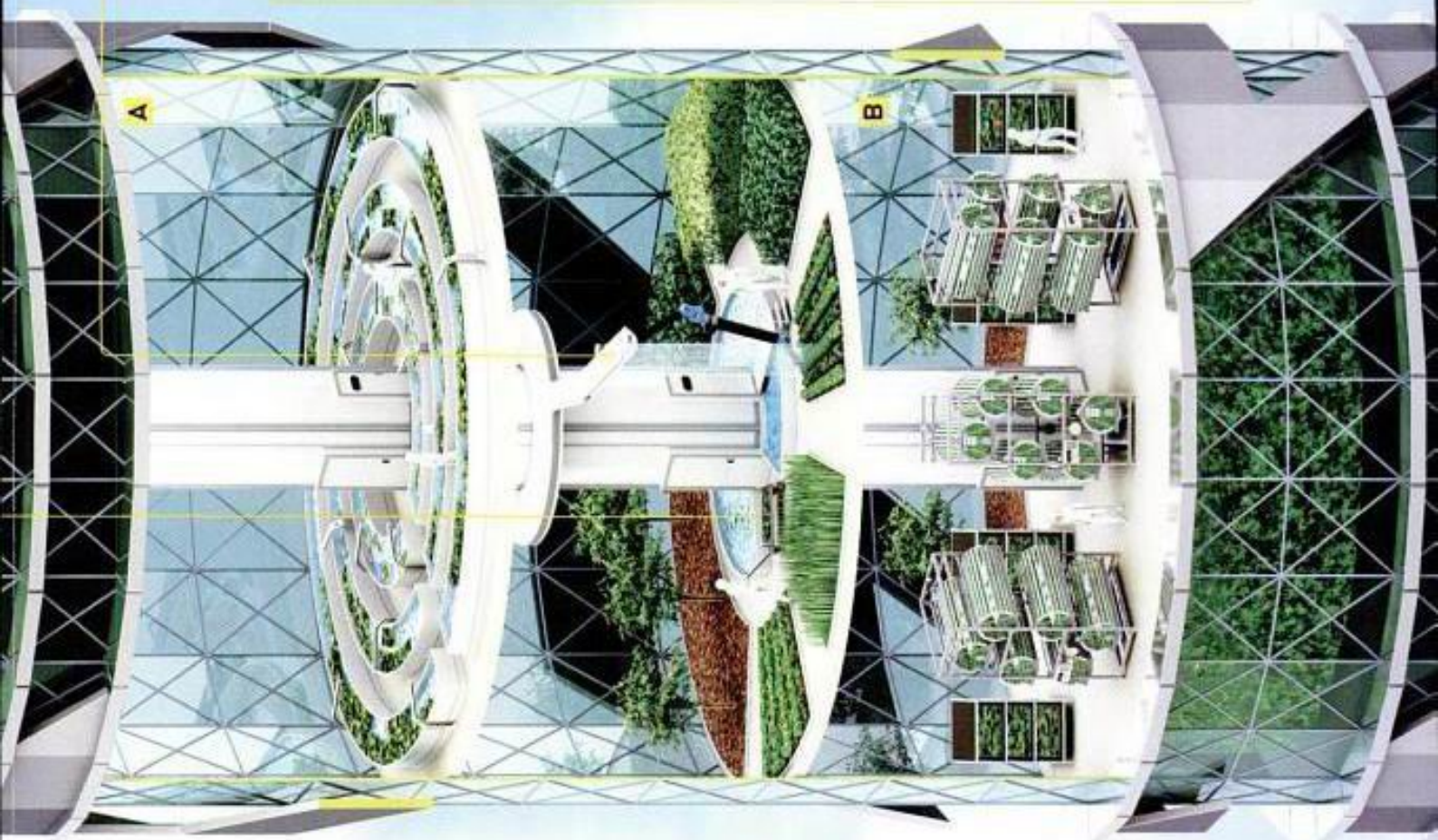
B CROP CIRCLES TENDED BY ROBOTS

FARMERS ALREADY score per-acre yields using hydroponic tactics that are 30 times as high as those produced by traditional farming. In a vertical farm, nutrient-delivery machinery and 24-hour light exposure would improve on that yield many times over.

But not all plants respond well to hydroponic methods. Some, such as potatoes and cit-

rus trees, need to set root in a semisolid medium, like soil or coconut fiber. The design here, by the Canadian company Omega Garden, does just that. In this Ferris-wheel-like growing system, plants grow in porous, vermiculite-stone-filled trays [1] arranged in a cylindrical cart [2] that rotates to periodically dip each row of plants in a nutrient trough [3].

Robotic arms equipped with mechanical noses "sniff" plants and harvest them based on the presence of specific alcohols, a more precise judge of ripeness than color.



■ OLD MACDONALD HAD A LAB COAT

PLANTS DON'T HAVE millions of years to adapt to indoor hydroponic growth cycles, so botanists must select and breed the strains that perform best. Other scientists will blend specialized fertilizers for the plants so that they'll contain micronutrients essential to the human diet, like selenium and zinc.

EVEN A FEW INSECTS or pathogens could decimate the enclosed crops, so farmers entering the building must don containment suits and pass through airlocks. Scientists will coat plants with genetically modified bacteria that glow in the presence of a threatening disease or pest, alerting farmers to an outbreak.

RAISING CATTLE is inefficient—only 3 percent of the energy used to raise a cow ends up as protein on your plate. Instead, scientists will cultivate slabs of meat in the lab from chicken, pig or cow stem cells raised on a diet of water, glucose and natural proteins. To approximate the texture of meat, they will "exercise" the muscle with electrical pulses. The fatty texture of a porterhouse is too complex to replicate, but sausage and chicken nuggets should be routine in a decade.



■ THE WHOLE THING RUNS ON SEWAGE

The vertical farm converts 100 tons of sewage into 19 megawatts of electricity.

THE VERTICAL FARM is more than just a produce factory. It's also a plan to rewire a city's infrastructure to mimic natural-resource cycles. Nowhere is that more evi-

dent than in the solid, coal-like slurry burns to power steam turbines [3] that generate electricity. The rest of the sewage is treated with bacteria-killing chemicals

Chickens require little space and yield one pound of meat per two pounds of feed—very efficient by farming standards.

dent than in the tower's basement, where sewage provides the farm's most crucial resources: energy and water. The surrounding city's sewage system would be redirected to the farm, where half of it would enter a "SlurryCarb" machine, developed by EnerTech, a green-energy start-up in Atlanta. The device heats and pressurizes the sludge [1], breaking it down into its base components—carbon and water. The machine extracts the



Neighbors purchase vertical-farm goods in the tower's ground-floor grocery store, and electric trucks deliver food to local markets.



SUPERMARKET



The Electric Experience

By Ron Cogan

What, exactly, are you getting into if you decide an EV1 is for you?

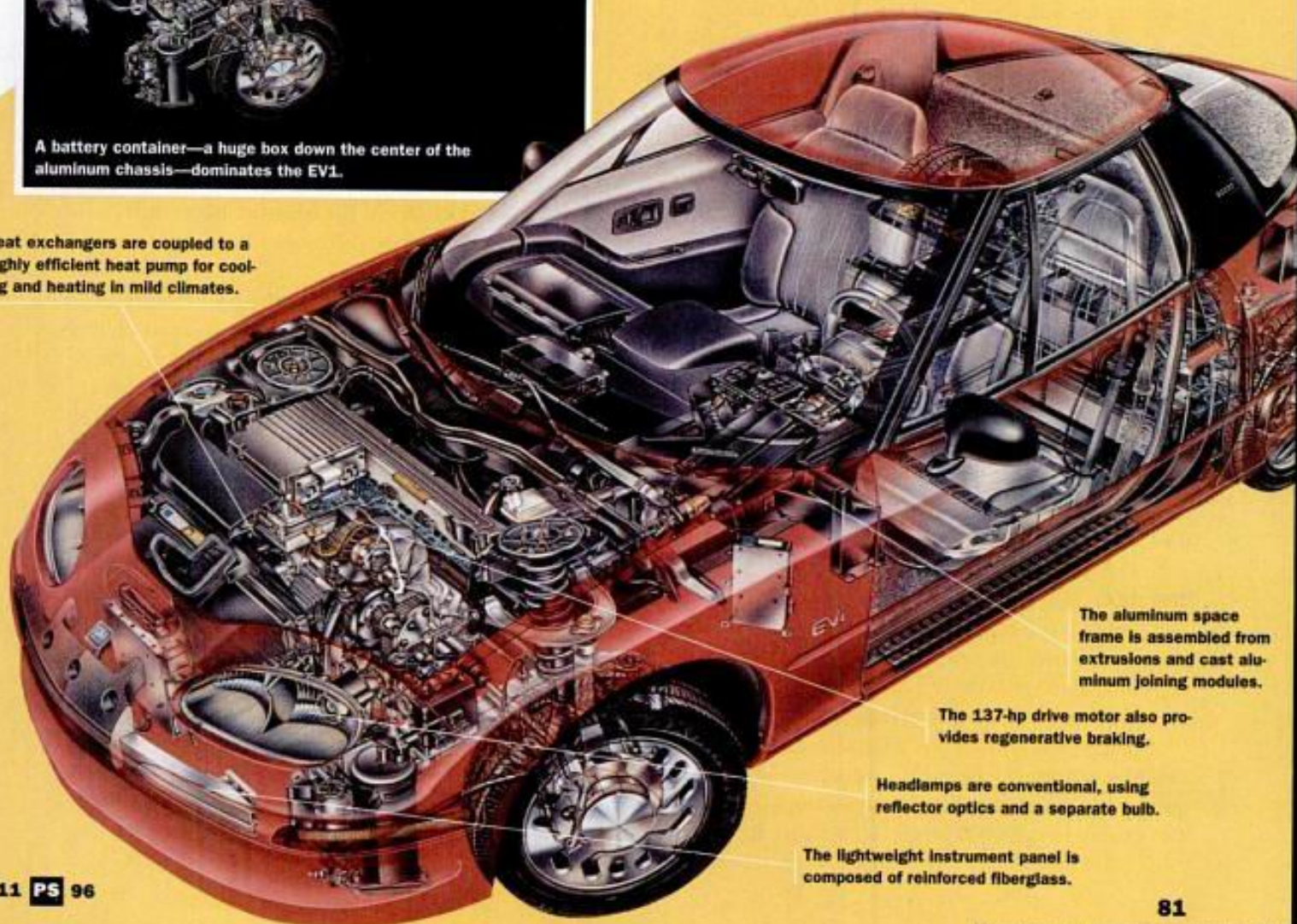
THE FIRST KICK at the high-pressure sidewalls of the ultra-low-rolling-resistance tires of GM's EV1 underscores the fact that the first electric car being marketed to the general public in decades is, well, different.

The difference is more fundamental than the mere fact that the EV1 is powered by a 137-horsepower, three-phase, AC induction electric motor that taps the stored energy of



A battery container—a huge box down the center of the aluminum chassis—dominates the EV1.

Heat exchangers are coupled to a highly efficient heat pump for cooling and heating in mild climates.



The aluminum space frame is assembled from extrusions and cast aluminum joining modules.

The 137-hp drive motor also provides regenerative braking.

Headlamps are conventional, using reflector optics and a separate bulb.

The lightweight instrument panel is composed of reinforced fiberglass.

In the event an EV1 does suffer a malfunction, the defective component will be removed and replaced by the dealer. The defective part is then sent back to GM for testing to determine why it failed—part of a continuous quality improvement effort. EV1 parts will be stocked at regional warehouses and delivered to the dealer either the same day, or the next. Battery packs will be provided via next-day delivery by Delco Propulsion Systems. Delco will also receive all end-of-use batteries from GM electric vehicles for recycling. (The batteries are 95 percent recyclable.)

When an EV1 is damaged in an accident, repair work on the aluminum structure and fiberglass body panels will be handled by an authorized Saturn dealer.

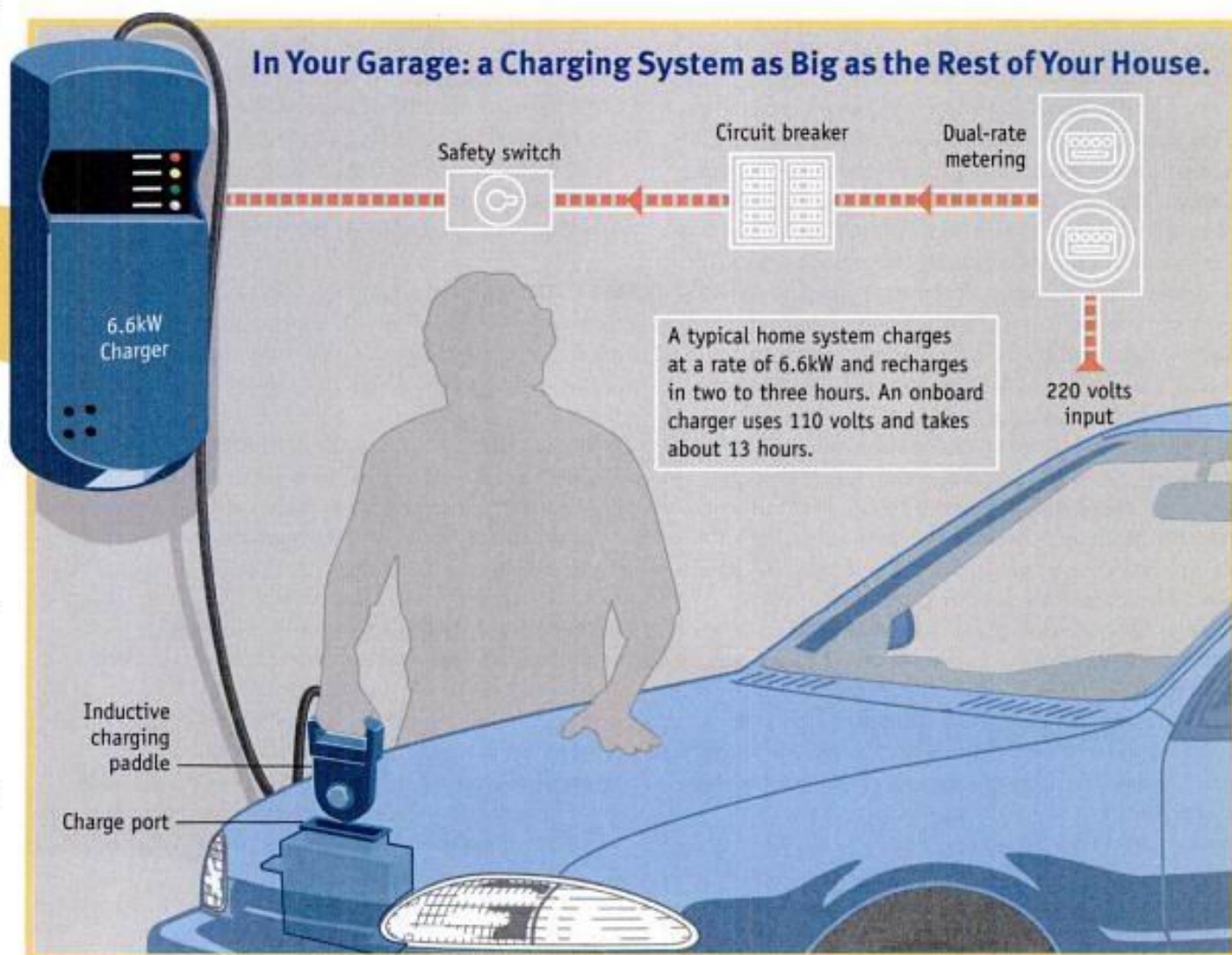
EV1 customers are encouraged to not stray too far from the car's initial marketing areas, since authorized service will not be available. While roadside service is included as part of the three-year lease, it's likely that towing charges outside of these Saturn dealers' assigned territories will be borne by the customer.

ON THE ROAD Slide behind the wheel of the EV1 and it's impossible not to notice something's missing. For starters, there's no ignition key. In its place is an elec-

tronic keypad that activates onboard systems in response to a secret code. Also gone are a few things to which we've grown accustomed, like water temperature and oil pressure gauges, and shifter selections that go beyond park, reverse, neutral, and drive. (A single-speed drive unit obviates the need for low gear and overdrive.)

Plenty of familiar features remain, though, including a Delco AM/FM/CD/cassette stereo system and such everyday accoutrements as power windows, heating and air-conditioning controls, speedometer, trip odometer, and a variety of status indicators. But some new twists are also offered, such as displays for state of charge, time to full charge, vehicle range, and passenger-compartment environment preconditioning.

Preconditioning is one of those interesting byproducts of electric vehicles that, once tried, will forever be among an EV driver's favorite features. While the EV1 is connected to a charger, it can be programmed so its innovative heat pump automatically heats or cools the car's interior to a desired temperature at a specific time...say, about 10 minutes before you're ready to head for work. If you plug in again at the work site, this same feature can also condition the interior to a comfortable temperature for your drive home.



CATEGORY: MODULAR DOMESTIC
BREAKTHROUGH TECH: BALANCING PODS,
AUTONOMOUS DRIVE, VERSATILE CONFIGURATION

SNAP!

MULTICAR

BREAKING UP IS EASY

Behold the most flexible family car ever devised. It's not just one car—it's two, or three or four. Imagine you're driving to the shore. Your daughter wants to see her friends, your son wants to surf, and you and your wife want to hit the boardwalk. No need to play taxi. This groundbreaking new sedan is made from four independently drivable pods. When attached as a single car, the side windows rotate open to allow for side-to-side interaction, with a high-fidelity microphone system for clear front-to-back conversation, as well. If the passengers want to split up, each driver enjoys either hand controls or, particularly for younger, not-yet-road-legal children, the latest in fully autonomous driving capabilities.

BIG WHEELS

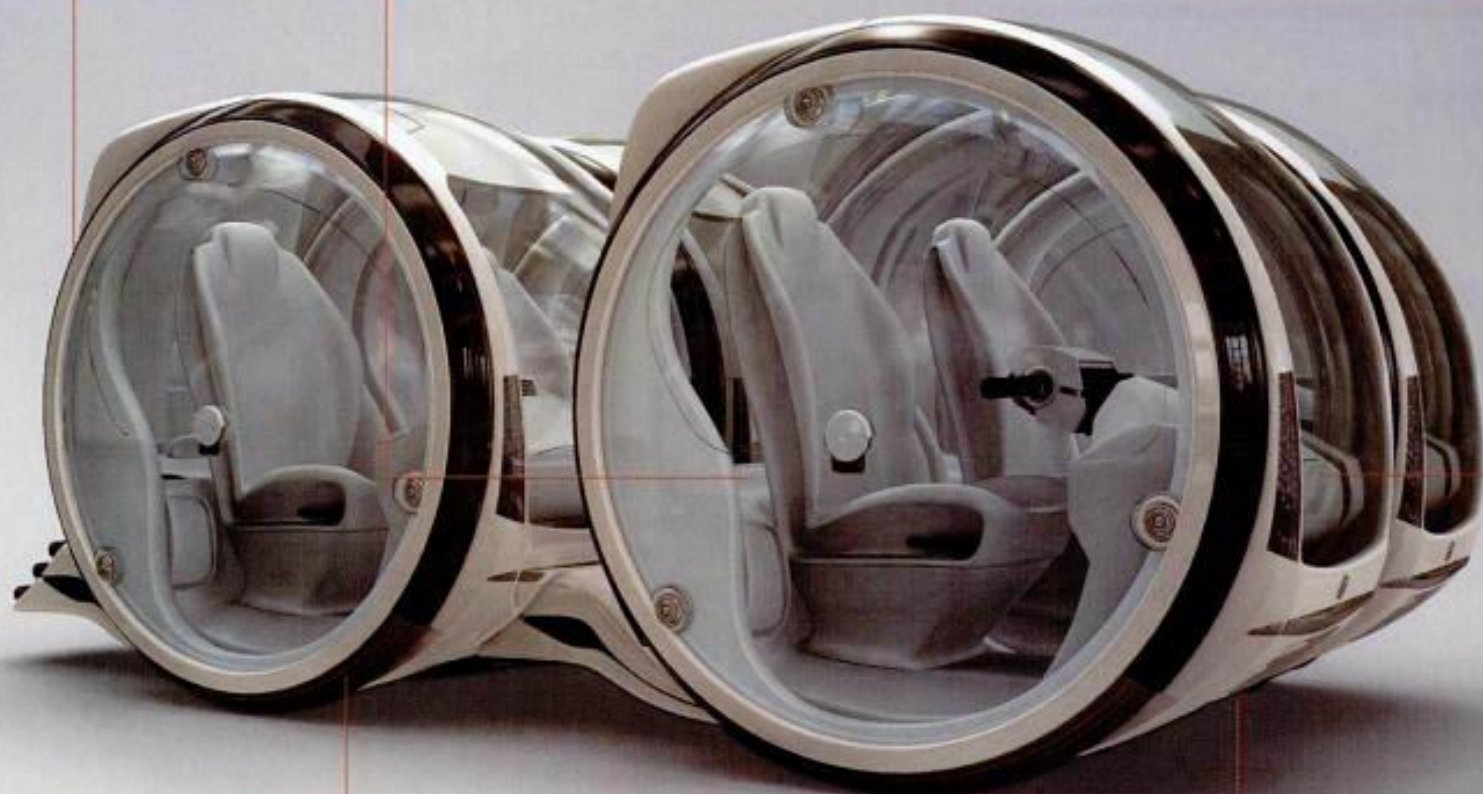
Two full-height, hub-motor-powered wheels frame each pod.

JOINING FORCES

Each pod has its own power source. When combined, the motors work together to drive the sedan. An onboard computer manages power to each motor.

BALANCING ACT

Individual pods balance with the help of accelerometers and gyroscopic sensors that detect instabilities and instantly adjust the relative speed of each wheel to keep you upright.



CORNERING ON RAILS

Individually and when connected, the pods steer by varying the relative speeds of the wheels—almost like a tank—or, at higher speeds, a slight pitching of each wheel to the left or right.

THIRD WHEEL

Because balanced driving for individual pods works best under 20 mph, a deployable third wheel extends from the front of each car to permit pods to safely reach 50 mph. Top speed of two or more pods joined together: 150 mph.



CATEGORY: **HEAVY TRANSPORT**

BREAKTHROUGH TECH: **DYNAMIC DISPLAYS, AUTONOMOUS DRIVE**

NOMAD

R O A D T R A I N

MAKES GETTING THERE HALF THE FUN

It's the first hands-off big rig. Need to send a shipment autonomously from Las Vegas to Tahoe? Program the route and schedule, and let it go. Need to bring a crew with you or have the added flexibility of a human driver who can handle tight maneuvering and cargo management and supervision? The Nomad can be customized for any business. Here, a professional racing team's truck comes complete with a luxurious crew deck upstairs, a fully functional garage workspace, and room for two racecars.

DIESEL GRUNT

700-horsepower clean-diesel engine underneath the crew deck generates enough power to haul 40-ton loads.

BUBBLE CANOPY

The wraparound windscreen automatically adjusts its tint in harsh sunlight.



CREW DECK

Cabin seats six or eight in comfortable chairs that recline to full beds. LCD and holographic entertainment systems, as well as a bathroom and kitchenette, come standard.

VARIABLE WINDOW

The floor-to-ceiling OLED windscreen on the crew deck can adjust from completely transparent to opaque for privacy.

EASY ACCESS

The driver's station connects to the crew deck through a central passageway.

LOW DRAG

Sleek, aerodynamic shaping, ultra-lightweight wheels and composite frame construction minimize weight and drag.

DYNAMIC SHELL

Transparent skin with embedded, digitally controlled OLED panels can let the sunshine in—showing off the team's handiwork to race fans on the road—or keep things dark for privacy. The entire structure can display still images or video.



TIGHT MANEUVERING

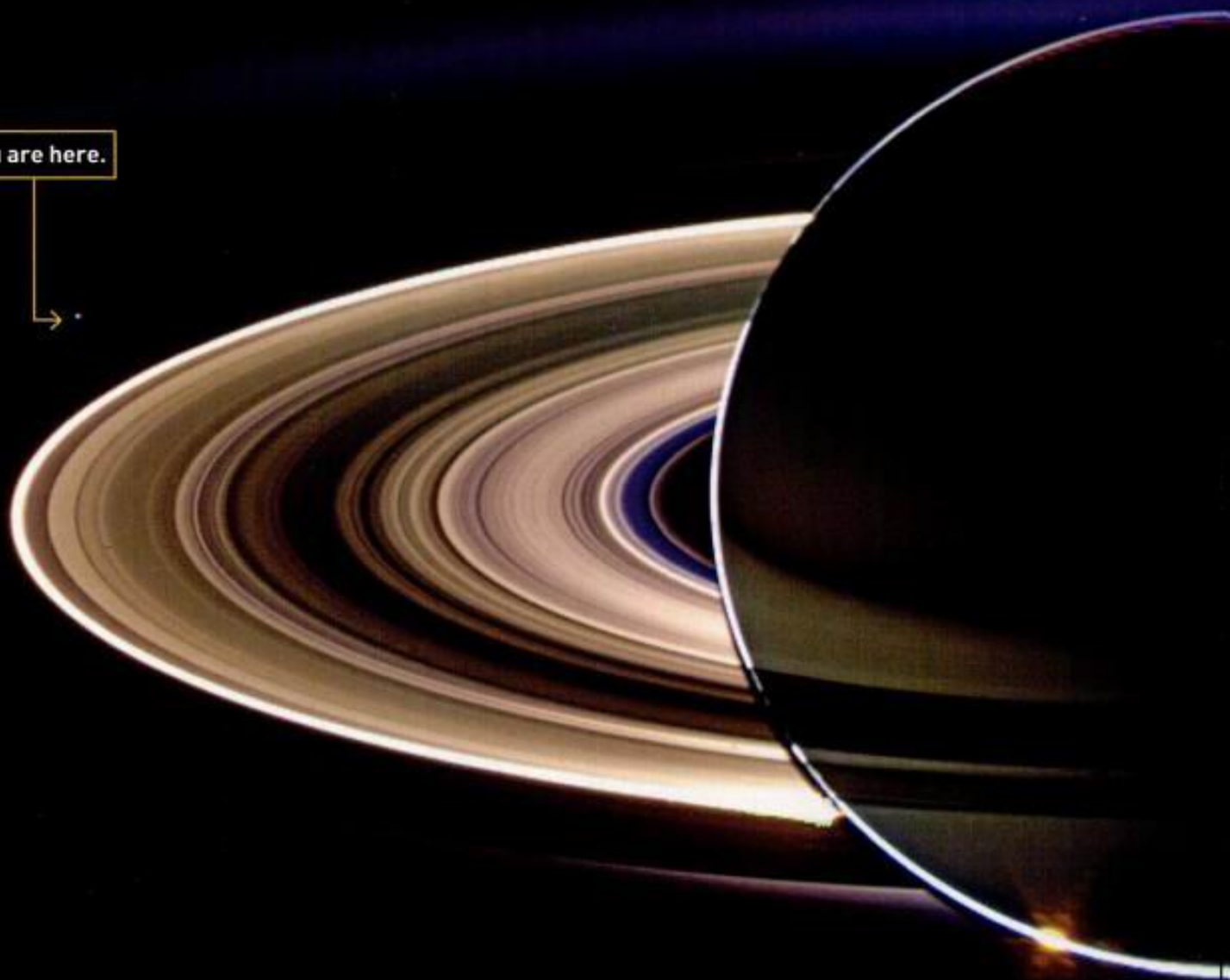
A flexible, weather-tight hinge between the truck and the trailer permits tight maneuvers without cutting off access between the two.

THE FOUR CONCEPT VEHICLES presented on these pages are based on interviews with designers and engineers at BMW, Lotus Engineering, Audi Design, Ford, General Motors, Jaguar, Segway, the Academy of Art University's School of Industrial Design and the College for Creative Studies. Research conducted by Eric Adams and Dan Lienert. Design and illustrations by Nick Kaloterakis [Javelin and SNAP!], Bob Sauls/Frassanito [Extender] and Peter Bollinger [Nomad].

MEGAPIXELS

THE MUST-SEE PHOTOS OF THE MONTH

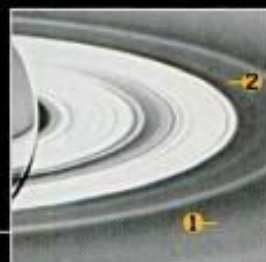
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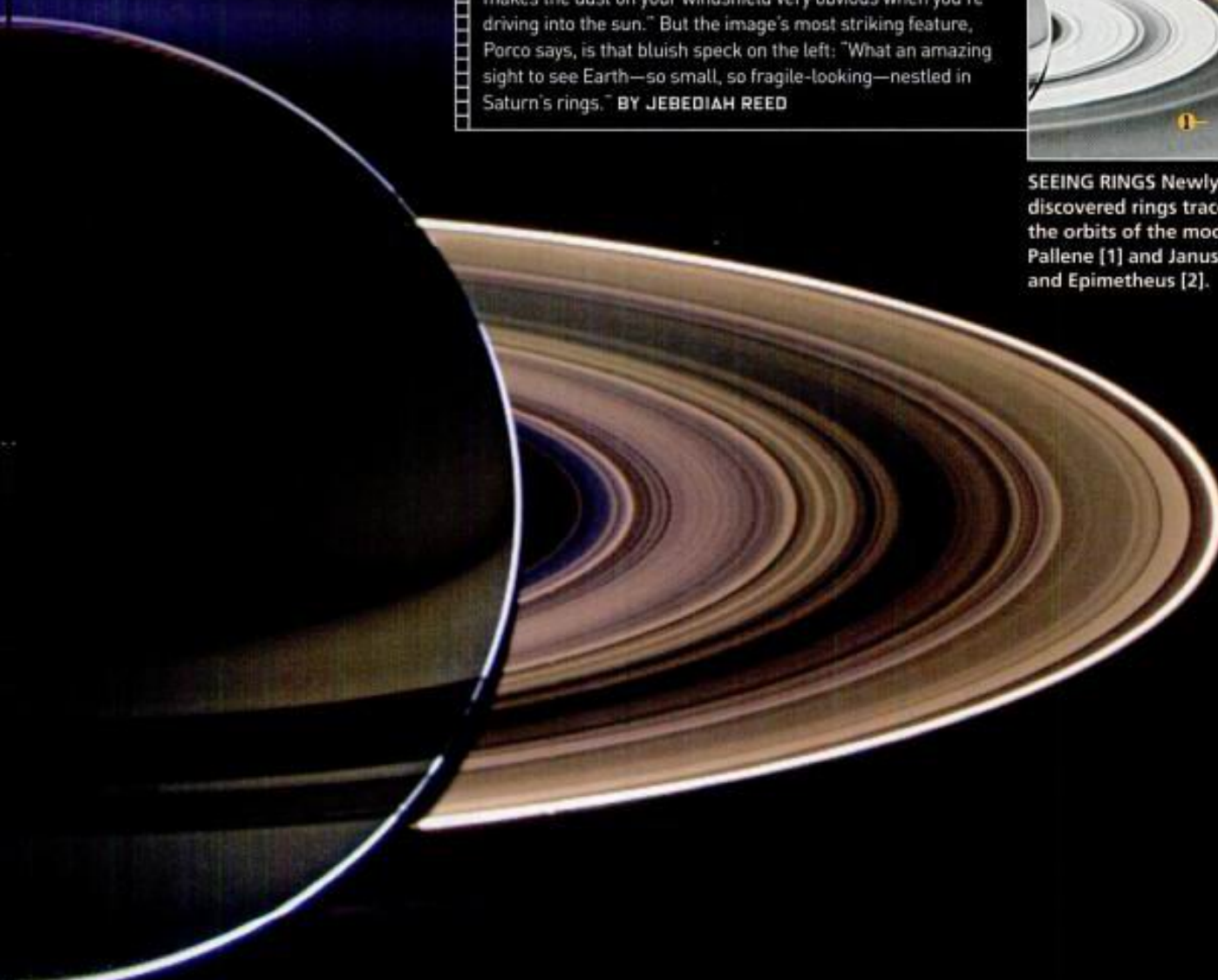
IN SATURN'S SHADOW

A bit of shade helps *Cassini* see new rings—and home

While traveling through Saturn's shadow last September, the spacecraft *Cassini* was able to shoot a remarkable series of photographs from a perspective that would normally fry its optics. The images, taken over the course of nine hours and combined here into a panoramic composite, capture for the first time the giant planet and its dazzling array of rings backlit by direct sunlight. The perspective has revealed two never-before-seen rings, faint bands of dust apparently thrown up by meteorites hitting moons. "The tiny particles are highlighted," says Carolyn Porco, leader of the *Cassini* mission's imaging team. "It's the same effect that makes the dust on your windshield very obvious when you're driving into the sun." But the image's most striking feature, Porco says, is that bluish speck on the left: "What an amazing sight to see Earth—so small, so fragile-looking—nestled in Saturn's rings." **BY JEBEDIAH REED**



SEEING RINGS Newly discovered rings trace the orbits of the moons Pallene [1] and Janus and Epimetheus [2].



1,200 SQUARE FEET UNDER THE SEA

BY MICHAEL BEHAR
ILLUSTRATIONS BY PETER BOLLINGER

For a 24-hour view of one of the most vibrant coral reefs on Earth, book a room at the world's first underwater hotel

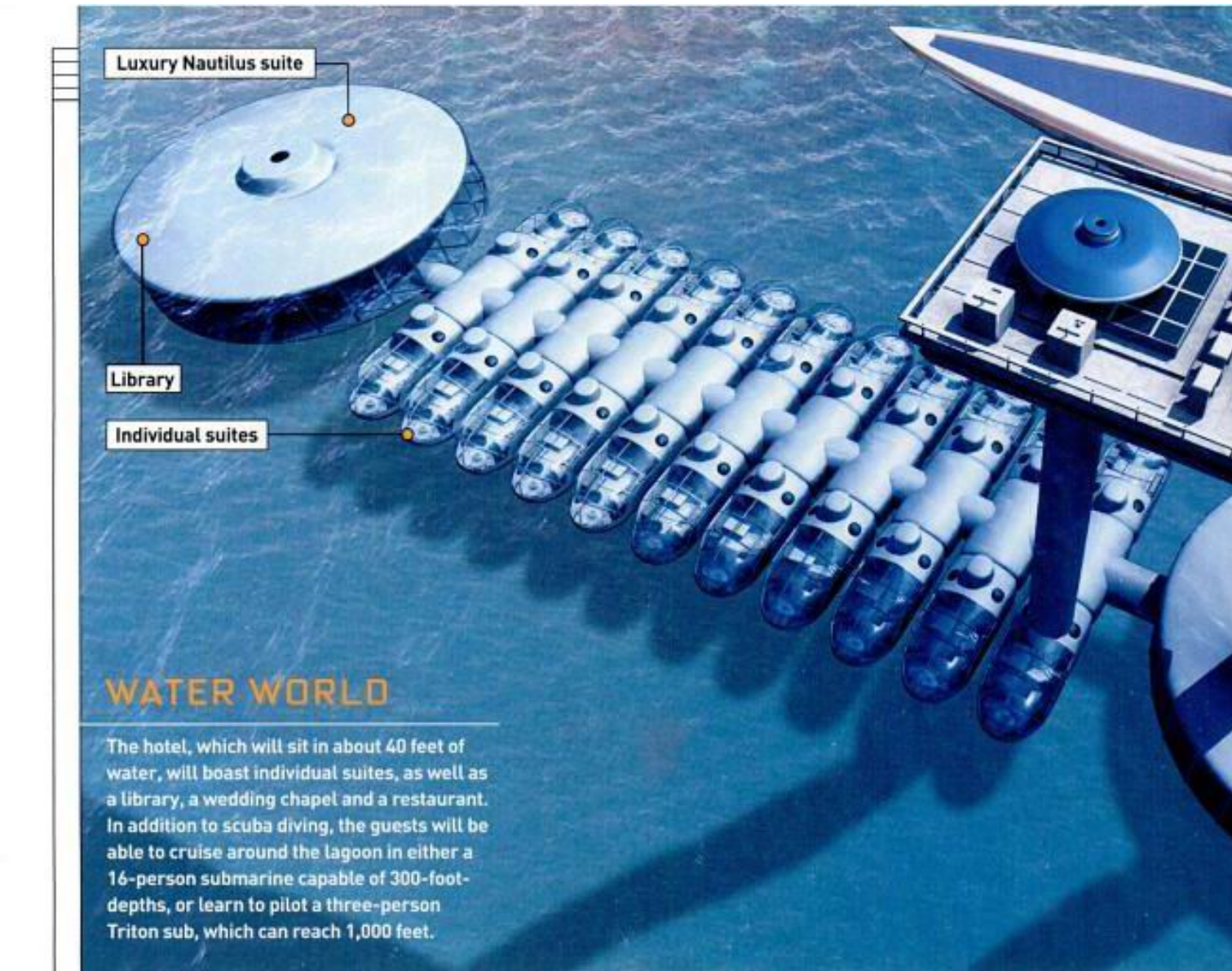
THREE KEY FACTS

- 1** Submarine builder Bruce Jones plans to build a luxury hotel **40 feet underwater** in a coral lagoon in Fiji.
- 2** The structure will be mostly **constructed on land**, then hauled to the site and lowered into place.
- 3** Poseidon will have **24 guest rooms**, a \$15,000-per-night suite and a wedding chapel.



BRUCE JONES has spent much of his career designing underwater toys for the rich and famous. The 50-year-old president of U.S. Submarines is best known for building ultraluxe custom subs, \$80-million vessels that feature private staterooms, paneled interiors made from exotic hardwoods, plush carpeting, and enough onboard oxygen to keep you and 10 friends breathing easy for three weeks of cruising at depths of nearly 1,000 feet. Now Jones is redirecting his expertise in undersea opulence toward the hotel industry. His plan: to open the Poseidon Mystery Island, the world's first major resort at the bottom of the ocean, by September 2008.

"When I was in high school, I was always writing letters to Jacques Cousteau and sketching underwater habitats," Jones recalls. In 2000, he took the first step toward the real thing, offering a reward to whomever found the best location for his future



Luxury Nautilus suite

Library

Individual suites

WATER WORLD

The hotel, which will sit in about 40 feet of water, will boast individual suites, as well as a library, a wedding chapel and a restaurant. In addition to scuba diving, the guests will be able to cruise around the lagoon in either a 16-person submarine capable of 300-foot-depths, or learn to pilot a three-person Triton sub, which can reach 1,000 feet.

undersea playground. "I've got a lot of friends in the submersible business who are also scuba divers," he says. "So I put the word out that if someone came up with the perfect spot, we'd pay them \$10,000." A business associate and avid diver suggested a reef off the Bahamian island of Eleuthera and collected his reward. But Jones eventually ran into trouble negotiating a price for the site with its American owners. After a year of fruitless back-and-forth, he decided to set his sights farther afield, on Fiji.

DIVING IN FEET-FIRST

Jones is not the first to pursue an aquatic hotel. That credit goes to Jules' Undersea Lodge (named, of course, for seafaring scribe Jules Verne), a little bungalow at the bottom of the Emerald Lagoon in Key Largo, Florida. Opened in 1986, Jules' is more akin to a sunken

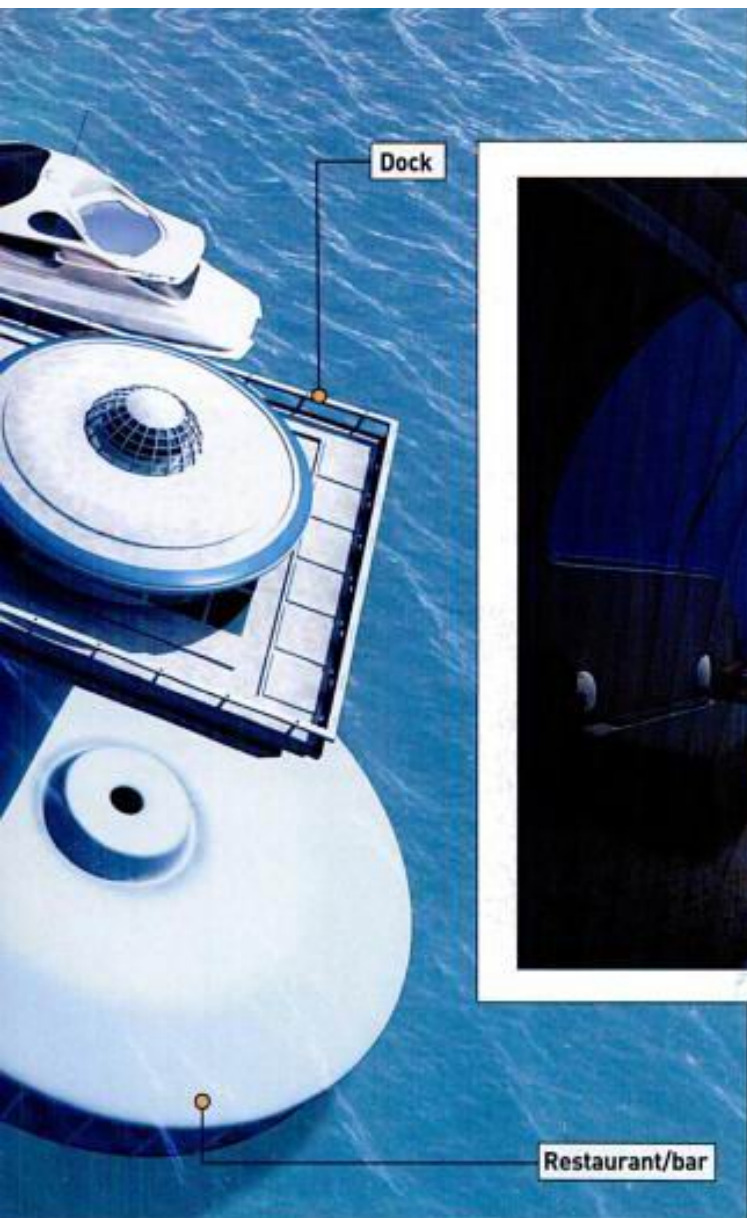
A Frisbee-shaped end module will house a reception lounge and a 3,000-square-foot rotating restaurant and bar.

RV than a full-fledged resort. Up to six guests can rent the two-bedroom, one-bath undersea retreat for the night, but scuba certification is mandatory; the front door is 21 feet underwater.

In Dubai, where hotels are prized for ostentation, a group of commercial developers is hyping the creation of the \$500-million Hydropolis Undersea Resort. A sprawling 1.1-million-square-foot complex—with lavish suites, a ballroom, a shopping mall and a missile-defense system to ward off terrorists—Hydropolis is an ambitious vision of luxury at 60 feet underwater. As of press time, though,

the project had stalled in the pre-construction phase. According to Mansoor Ijaz, deputy chairman of the board for Crescent Hydropolis Resorts, LLC, Hydropolis is on hold pending "land acquisition" and probably won't be finished before the current opening date, set for 2008.

Money, naturally, is the first hurdle facing any large-scale endeavor. In the case of Poseidon, private investors and an American merchant bank have anted up nearly all of the \$105 million that Jones needs to complete the resort. Clearly, they are optimistic that Poseidon can lure enough celeb-



ROOM WITH A WATERY VIEW Each individual suite will be 550 square feet large, will feature a Jacuzzi, and will be capped by four-inch-thick acrylic windows, which make up about 70 percent of the wall space. Fish feeders will fire food into the water to attract local wildlife. To prevent overfeeding, the system will be limited to a prescribed number of cartridges each day.

rity guests and high rollers to be a financial success. Meanwhile, Jones has inked a deal with the owners of a privately held South Pacific island. If all goes well with construction, the Poseidon Mystery Island will soon be submerged in 40 feet of water in a 5,000-acre coral lagoon near the coast of a narrow, 225-acre isle located in northeastern Fiji.

ROOM WITH A VIEW

Jones designed Poseidon to provide guests—scuba aficionados and landlubbers alike—with an all-inclusive vacation package: fine dining, stunning views of the surrounding lush coral habitat, and the opportunity to dive directly from the hotel's airlock, a hatch that lets divers out but keeps the sea from flooding into the hotel. Once the resort opens, visitors staying in one of the 550-square-foot guest rooms will

enjoy a 270-degree view of the vibrant coral reef and tropical fish, visible through floor-to-ceiling windows and illuminated by external flood lighting. Guests will access the hotel through two elevators. Because the interior pressure will be held at one atmosphere (the same pressure as onshore), they won't have to worry about getting decompression sickness. A Frisbee-shaped module at one end of the resort will house a kitchen, reception lounge and 3,000-square-foot rotating restaurant and bar. A second saucer will enclose a library, a conference room, a wedding chapel, a spa and the largest underwater accommodation in the world, the 1,200-square-foot "Nautilus" suite priced at \$15,000 a night. To ensure that guests always have a crystal-clear view of the teeming marine life, Poseidon will have an automatic window-cleaning system (barnacles, algae and other marine crea-

tures cling to just about anything in the sea). High-powered water jets will glide along tracks mounted to the sides of the resort, spraying the windows with high-pressure seawater, filtered so as not to coat the acrylic with barnacle larvae or other critters—a mechanism modeled after the cleaning jets in an automated car wash.

If the windows of a guest module become damaged, or if the room requires other repairs, maintenance workers can detach it from the main body of the resort and bring it to the surface. To loosen the joint that connects each suite to Poseidon's "spine," workers will close the watertight doors separating the guest module from the spine and then pump the joint full of seawater. As the hydrostatic pressure increases inside the coupling, it will force the suite loose so that an overhead crane can hoist it out of the water.

TO BRUCE JONES'S LOCKER
Each module is attached to the hotel's spine with a watertight double seal and can be detached for maintenance.



IN PROGRESS The \$15,000-a-week package includes two nights in the underwater suite and five days onshore.



MYSTERY ISLE The 5,000-acre coral lagoon that surrounds the island reaches a depth of 90 feet.



HOME BASE The Poseidon Mystery Island is located in the Northern Lau group, in the northeastern section of Fiji.

BUILD IT AND THEY WILL COME

First, however, Bruce Jones must build the thing. To keep costs down, the entire structure will be assembled in a shipyard in Portland, Oregon, and transported by a heavy-lift ship to Fiji. Meanwhile, engineers will drive guidance pilings into the seafloor. The hotel will float off the ship in one piece, and divers will thread small metal rings, bolted to the hotel's exterior, onto the pilings. These pilings keep the structure aligned until divers can pin the hotel's steel legs to the reef. The whole structure is then ballasted until it sinks to the seabed.

The trickiest part of building Poseidon, Jones says, is acquiring the huge sheets of transparent acrylic required for the windows in the guest rooms and the restaurant and bar area. A few manufacturers could produce the acrylic in the sizes he needs, but the cost would bank-

The trickiest part of building Poseidon is making the huge sheets of transparent acrylic without bankrupting the entire project.

rupt the project. So Jones has decided to fabricate it himself. Poseidon's five engineers, each a submarine designer with at least 13 years of experience working at U.S. Submarines, will design and build a specialized autoclave for forming both the curved four-inch-thick acrylic windows in each room suite and the floor-to-ceiling panes in the end modules.

Like so many other ambitious hotel-resort plans, Poseidon must overcome unenviable logistical hurdles before the first guest walks through the door. Other promising underwater projects have ground to a halt because of budget overruns and legal wrangling. Even funding and lagoon space isn't a surefire guarantee that Poseidon will ever be completed, although Jones's decision to pre-fab the hotel, rather than risk the vagaries of underwater construction, tips the odds in his favor. Finally, some industry analysts are skeptical that the pool of potential guests is large enough to keep the hotel afloat. But Jones is confident that he will be taking guest reservations for Poseidon—and that guests will pony up the \$15,000-per-person, per-week reservation fee—for a long time to come.

Michael Behar's last article for PopSci busted 10 myths about hydrogen fuel.

AVIATION & SPACE



MOUNT GRAHAM INTERNATIONAL OBSERVATORY LARGE BINOCULAR TELESCOPE

THE FARTHEST-SEEING TELESCOPE EVER BUILT

With 10 times the light-collecting power of Hubble, the world's highest-resolution optical telescope exposed its twin 27.6-foot mirrors for the first time last January. Those mirrors, made of a compound called borosilicate that collects more light in less space than previous materials, should allow the scope to see planets orbiting distant stars. medusa.as.arizona.edu/lbto

PIPISTREL TAURUS ELECTRO THE LONGEST-FLYING ELECTRIC PLANE YET

The first two-seat battery-powered airplane, the Taurus Electro gives pilots the quiet-as-a-bird flight of a glider coupled with the practicality of a powered aircraft. Two lithium-polymer battery packs drive a top-mounted propeller, so the Electro can take off from a runway like a typical plane. Once airborne, the Electro switches into glider mode and rides thermal currents back to earth. A 31-pound electric motor makes it all possible by providing 30 kilowatts of power. Although the Taurus Electro is still classified by the FAA as "experimental," Pipistrel hopes to change that ruling and start selling it by next year. pipistrel.si

JAXA KIZUNA BROADBAND SATELLITE THE FASTEST INTERNET, FROM SPACE

Kizuna, launched by the Japanese space agency JAXA in February, will deliver to remote areas of Japan and Southeast Asia the fastest satellite Internet connections ever—up to 1.2 gigabits per second, or 500 times the average American consumer connection. Unlike previous satellites, Kizuna is powerful enough to supply industrial-speed signals to small, inexpensive antennas on the ground. Another first: It tracks the weather and adjusts signal strength for specific regions accordingly; for example, it will send a stronger signal to an area where it's raining in order to penetrate the storm. jaxa.jp/projects/sat/winds

SCALED COMPOSITES WHITEKNIGHTTWO SPACE TOURISM HAS LIFTOFF

THE SKY'S NO LIMIT *WhiteKnightTwo's* job is to carry *SpaceShipTwo* (the smaller vehicle between the outer hulls) to its launch altitude.



With the wingspan of a B-29 bomber, the *WhiteKnightTwo* is the largest all-carbon-fiber aircraft ever built. Its mission is to carry a smaller craft, *SpaceShipTwo*, and drop it at 48,000 feet, where it will blast off into suborbital space with paying passengers—in 2010, if all goes well. Virgin

Galactic's CEO, Richard Branson, also wants to use *WhiteKnightTwo* as a low-cost way to launch satellites into orbit. Scaled Composites engineers had to overcome numerous setbacks, including a fatal explosion at the company's headquarters, to finish the craft. virgingalactic.com



A high-resolution satellite photograph of Area 51, showing a complex network of roads, runways, and various buildings. The terrain is arid and mountainous. The image is oriented horizontally on the page.

TESTING GROUND Satellite imagery taken on January 17, 2006, of Area 51 reveals little. Base security personnel know when satellites are passing overhead, and test aircraft remain indoors at those times. Personnel work in windowless offices and are locked inside when anything other than their own project is outdoors.

NEW SECRETS OF AREA 51

Mysterious commuters, unexplained sonic booms, and big spending at this top-secret desert outpost suggest a surge in classified military aircraft—and hint of one long-rumored speed demon's steady progress toward reality

BY BILL SWEETMAN

THREE KEY FACTS

- 1** Classified, or "black," programs produced the **U-2** and **SR-71** spyplanes.
- 2** Studying vague budget allocations and **gaps in military forces** can uncover black projects.
- 3** Programs can linger for years until **key technologies** are developed.

ON A TRIP TO LAS VEGAS in 2004, observing from my east-facing hotel room in the pyramidal Luxor Hotel at daybreak, I watched a fleet of six unmarked 737s make commuter flights to nowhere. These aircraft depart every weekday morning from a tidy, anonymous terminal on the western side of McCarran International Airport. A long line of cars pours into a 1,600-spot parking lot as the jets pull away from the terminal, taxi to the runways, and head out into the desert sky. At the end of the day, the shuttle flights return and the lot empties. The passengers go home and tell their families nothing about what happened at work that day.

Cut to April 4 this year. San Diego is hit by a rumbling shock that isn't an earthquake. It is ruled out by the media as a sonic boom after military operators claim it is not one of their aircraft. *San Diego Union-Tribune* reporter Alex Roth does some digging and comes up with six puzzlingly similar incidents around the country since 2003.

Fast-forward to July, at the Farnborough International Airshow in southeastern England. Frank Cappuccio, the avuncular vice president of Lockheed Martin's secretive Skunk Works division, opens a press conference by introducing what he calls a promotional video, "something to show the kids and families about what we do." Two minutes into the show, a gray, cockpit-less airplane that nobody has seen before—it looks like a B-2 bomber's chick—soars over a backdrop of stony, barren hills and mountains.

All these events are linked. They are the visible signs of an invisible, parallel world within the universe of aerospace

and defense: the classified, or "black," world of secret military programs. Those unmarked 737s were ferrying employees to the flight-test center near Groom Lake, Nevada, known to the public as Area 51. The gray airplane is Polecat, a next-generation stealth unmanned aerial vehicle (UAV)—Cappuccio's video was his sly way of unveiling the program. Those earthquakes? Quite possibly sonic booms from a long-suspected hypersonic attack vehicle, a sleek aircraft that has consumed the imaginations of black-project enthusiasts and military analysts, including me, for two decades. Though seemingly dormant in recent years, the program appears to be on the move again, and with a renewed vigor that has me feeling, somewhat unsettlingly, a bit like the aerospace industry's own Ahab.

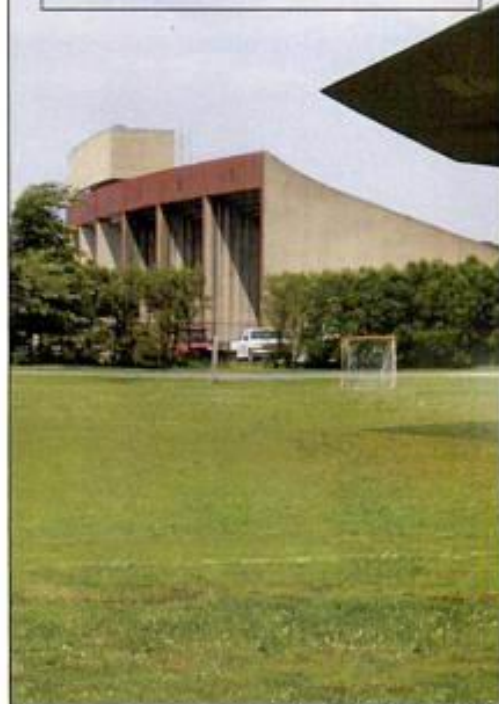
The black airplane world has, without question, produced the most significant advances in aviation technology. In the 1950s, it spawned the U-2

SPECIAL-OPS INFILTRATOR

THE VEHICLE: Vertical-takeoff-and-landing aircraft for transporting special-ops forces to hostile areas

THE TECHNOLOGY: Blended-wing-body design with six jet engines powering lift fans and providing forward thrust

THE EVIDENCE: Patent filings, obvious gap in current arsenal, recent development of key technology



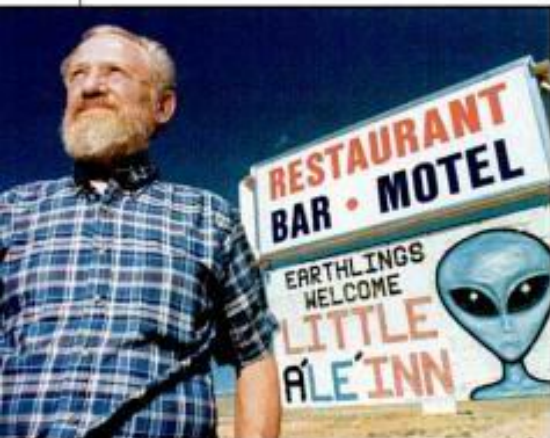
spyplane, which flew higher and farther than anyone had thought possible. It gave birth a decade later to the SR-71 Blackbird, the exotic, revered speed king. It also produced the slow but stealthy, origami-like F-117 fighter.

NOTHING TO SEE HERE...

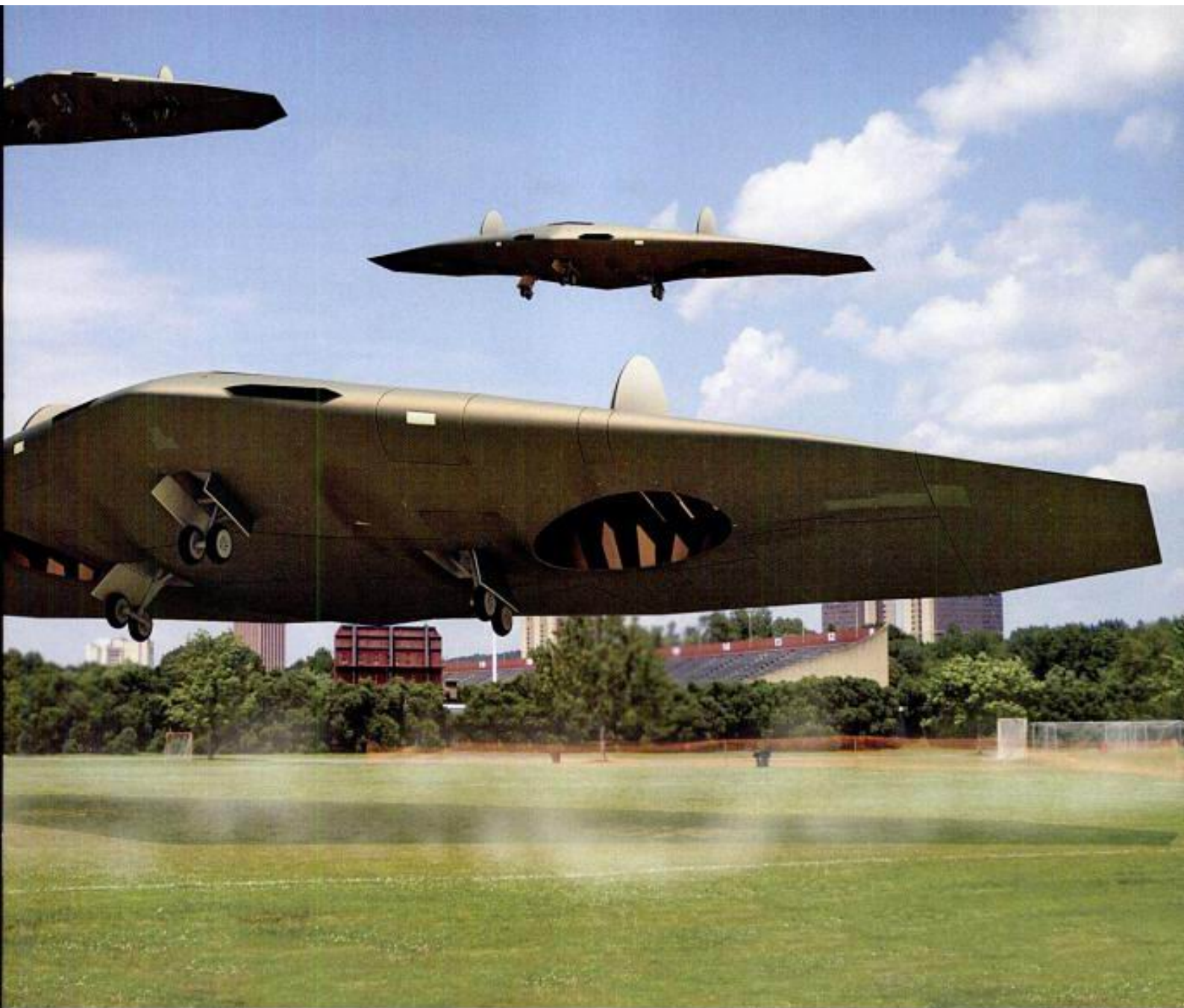
Passing through town? Don't get your hopes up—this ain't no Roswell

Area 51 is often mentioned in the same breath as Roswell, New Mexico. The two are actually 800 miles apart. Lore has it that aliens crash-landed near Roswell in 1947 and the military whisked their vehicles and bodily remains to Area 51 for study. Although Roswell has capitalized on the myth, Area 51's tiny local residential base—nearby Rachel,

Nevada, population 100—is more, well, discreet. But should you pass through Rachel, stop for a bite at the Little A'Le'Inn restaurant, shown here with its late owner, Joe Travis. Want to snoop around? The only vantage point for observers is Tikaboo Peak, unreachable in winter and 26 miles from the tightly secured base. Good luck!



PRECEDING PAGES: DIGITALGLOBE; THIS PAGE: JON FREEMAN/GETTY IMAGES



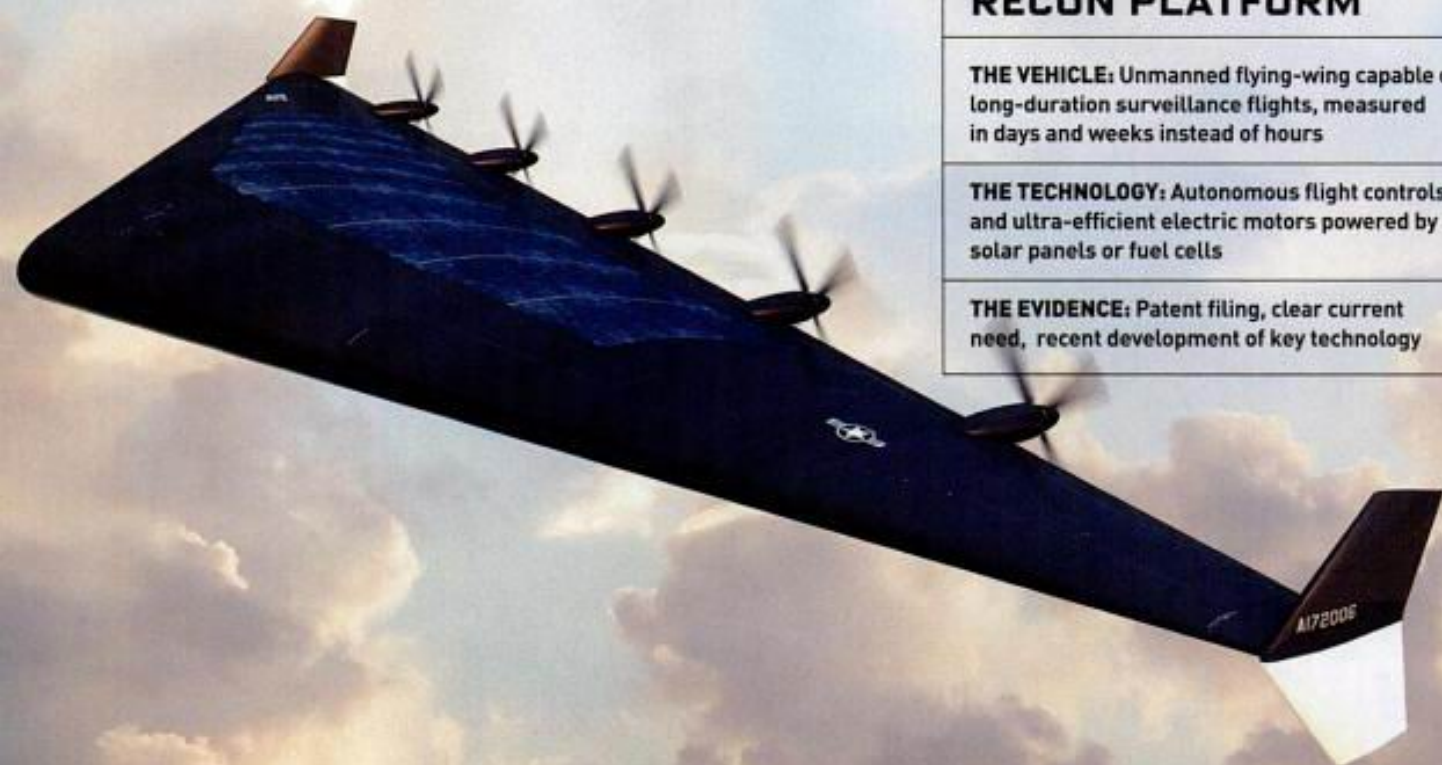
But for aerospace sleuths, there's been little activity recently in the form of declassified vehicles that might hint at current efforts. (Classified programs can be unveiled to aid in broad combat deployment or when the technology appears in other programs.) The F-117 came out of the black world during the first Iraq war 15 years ago, and only three aircraft have been introduced since. One was Polecat. Another was Northrop Grumman's ungainly reconnaissance aircraft *Tacit Blue*, nicknamed "the Whale." The third was Boeing's *Bird of Prey*, which tested visual stealth strategies, including shaping that minimizes shadows and contrast and, rumor has it, body illumination that allows it to blend into its background.

ANALYSIS OF THE EVIDENCE REVEALS TANTALIZING DESIGNS BEING COOKED UP ON THE SLY AT AREA 51.

This dearth of unveiled prototypes does not mean, however, that the black-aircraft community is dormant. In fact, all signs point to steadily increasing activity. Google Earth reveals a newly constructed additional runway and multiple new hangars and buildings at the base. The usual vague, untraceable allocations in congressional budgets that often signal classified programs are on the rise, and modern technological innovations are now enabling aircraft designs that might have floundered in the black world for years. Further, there

are significant gaps in the military's known aviation arsenal—gaps that the Pentagon can reasonably be assumed to be actively, if quietly, trying to fill.

The need for such secrecy is simple: It is essential to preserving technological surprise. The Pentagon wishes to prevent enemies from developing strategies to counter the technology. The challenge is to figure out what precisely is happening—without betraying national security—because the bigger the black world gets, the better it conceals its activities. What follows is



RECON PLATFORM

THE VEHICLE: Unmanned flying-wing capable of long-duration surveillance flights, measured in days and weeks instead of hours

THE TECHNOLOGY: Autonomous flight controls and ultra-efficient electric motors powered by solar panels or fuel cells

THE EVIDENCE: Patent filing, clear current need, recent development of key technology

inescapably an educated guess, arrived at by analysis of the available evidence, at the tantalizing designs being cooked up on the sly at Area 51, including a radical special-forces transport, a stealthy UAV, an agile new bomber, and my own white whale—the mythical, hypersonic dragster and presumed source of those faux earthquakes: Aurora.

DELIVERING SPECIAL FORCES BEHIND ENEMY LINES

One of the best pointers to a secret program is an obvious gap in the “white world” force, and one of these gaps is a stealthy, short-runway transport airplane. The U.S. Air Force’s special-operations community has talked for many years about stealthy transports that could take off and land vertically or on a few hundred feet of level ground (a soccer field is the classic example).

The new V-22 Osprey tilt-rotor transport is a partial answer to that problem, but the military would really

like something faster, so it can fly farther into and out of enemy territory, and the Osprey’s big rotors quickly betray it to radar. So far, there is no sign of unclassified, white-world money developing such a vehicle. In 1992, however, Skunk Works engineers filed a patent application for such an aircraft. (New aircraft can take years to develop. A 14-year-old patent filing could easily represent a current program.)

Tailless, with a blended wing and body, the aircraft is powered by six jet engines driving rotor-like lifting fans ensconced in wide, round bays in the wings. For takeoff and landing, doors and Venetian-blind vanes cascade open, and the fans lift the airplane vertically. While cruising, the engines drive smaller, forward-thrusting fans. Why six engines? The engines and fans are interconnected by an elaborate system of cross-shafts so that any engine can deliver power to either side of the airplane. With six engines, the airplane

can complete a mission if one fails.

Is something like that out there today? The job of a vertical-takeoff-and-landing aircraft still needs doing, perhaps now more than ever before, and, barring antigravity solutions from the friendly aliens at Area 51, an aircraft like this is one of the few ways to get it done. Technologically, it is probably benefiting from the innovations behind the Osprey’s power-sharing engines—in that aircraft, if one engine fails, the second still drives both propellers—and the development of the shaft-driven vertical-lift fan in the new F-35 Joint Strike Fighter, or JSF.

NEW UAVS: UNMANNED, INVISIBLE, UNLIMITED

Although manned fighter jets and bombers have long dominated classified programs, unmanned vehicles are rising as quickly in the black as in the white world, particularly because the Air Force lacks any kind of stealth-reconnaissance aircraft. It plans to replace the U-2 spy-plane with the Global Hawk UAV, but even though the Global Hawk has the advantage of being robotic—that is, capable of longer flights and expend-

THE NEED FOR ABSOLUTE SECRECY IS SIMPLE: IT IS ESSENTIAL TO PRESERVING TECHNOLOGICAL SURPRISE.

able, since there's no human on board—it doesn't fly as high and can't carry the same hefty high-performance cameras as the U-2. Nor does it carry a jammer to spoof enemy missiles.

Polecat, just outed from the black world, is part of the answer. Lockheed Martin representatives talk about an operational version with U-2-like altitude and payload, along with technology to avoid visual detection (including features seen on the *Bird of Prey*) and, perhaps, an automated system that detects a contrail behind the airplane and tells the flight-control system to change altitude.

Other stealthy UAVs have probably been tested—among them, possibly, armed UAVs. It is known, for example, that engine maker Williams International delivered the first dozen or so of its new FJ33 small jet engines to the U.S. government four or five years ago, but no known project uses that engine. A recent report in *Jane's International Defence Review* described another, larger vehicle that uses different engines from Polecat, apparently recycled from a 1960s UAV program. The article speculated that the engines are probably General Electric J97s, built for a UAV called Compass Arrow.

Why reuse old jet engines? There is only one good reason. The J97 was unusual in that it was designed to operate at up to 80,000 feet, an altitude at which most jet engines cough, stall, and quit. The Air Force does not send the stealthy B-2 and F-117 over hostile territory in daylight, because those planes could be easily spotted. But at 80,000 feet, six miles above a fighter's cruising altitude, the sky is almost as black as night, and a UAV could survive at high noon. I suspect that both Polecat and the second, larger stealth UAV are currently undergoing high-altitude flight-testing at Area 51.

Some UAV projects may be much slower than even the stealth birds. A Boeing patent filed in 2004 describes a vehicle that is a cross between an airship and an airplane—employing both buoyant lift from helium gas and wing lift generated by forward speed, and capitalizing on recent developments in on-board solar power generation and autonomous flight control.

What would be the advantage of such a vehicle? For one thing, it would have long flight endurance, measured in days or weeks rather than hours. For another, airships can easily be made to accommodate very large and sensitive

antennas. If you want to locate weak or sporadic radio transmissions—such as cellphones or scattered satellite phones used by insurgent groups—the airship is an ideal platform.

REVIVED AVENGER OFFERS STEALTHY GROUND ATTACKS

Another surprising gap in U.S. capabilities is the lack of an all-weather, stealthy ground-attack aircraft. The Joint Strike Fighter is supposed to do that, but not until 2014. The new F-22 Raptor, mostly an air-to-air fighter, will be able to do some of it eventually, but that jet carries a relatively modest 2,000-pound bomb load. The F-117 Stealth fighter can be flown only in clear nighttime weather—it has no radar to bomb accurately through clouds, and its black coating easily betrays it to ground spotters.

Fellow black-project sleuth Jeffrey Richelson, author of the 2001 book *The Wizards of Langley* and one of the leading historians of U.S. intelligence efforts, guessed in a recent conversation that a behind-the-scenes tour of Groom Lake might reveal a revived program to plug that gap sooner than 2014, when the JSF flies.

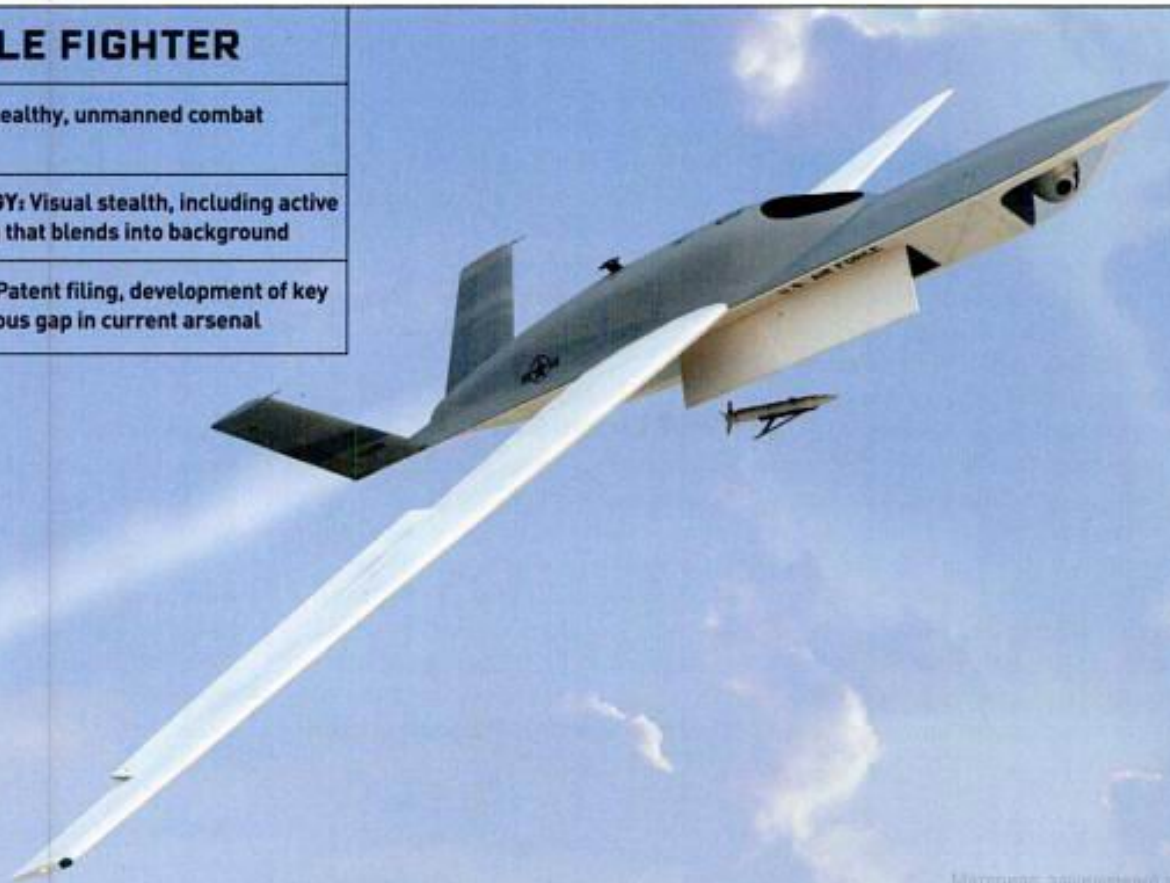
A hint about possible all-weather attack vehicles now in testing—ones

INVISIBLE FIGHTER

THE VEHICLE: Stealthy, unmanned combat aerial vehicle

THE TECHNOLOGY: Visual stealth, including active fuselage lighting that blends into background

THE EVIDENCE: Patent filing, development of key technology, obvious gap in current arsenal





ON-TIME DELIVERY

THE VEHICLE: Aurora Mach 6-plus attack aircraft

THE TECHNOLOGY: Ramjet-powered delta wing

THE EVIDENCE: Telltale sonic booms; unconfirmed sightings; unresolved history of long-rumored program; recent development of key technology; large, unexplained current budget allocation

AURORA WOULD BE AS FLEETING AS ITS NAMESAKE, LEAVING MORE OF AN IMPRESSION THAN AN ACTUAL SIGHTING.

available sooner than 2014 and capable of carrying significant bomb loads—could reside, aerospace historian Peter Merlin pointed out, in a test pilot's unclassified biography. Daniel Vanderhorst, who flew Northrop's Whale and six other secret aircraft in a 20-year career, evidently "tested modified landing gear and conducted initial tests of internal weapons bays and weapon separation tests." What's unusual about this is that most prototypes are simple aircraft without weapon bays, which suggests that this airplane was closer to an operational type. Specifically, I'm guessing, it could be an extension of the heavy-payload, all-weather attack jet A-12 Avenger II, which then-Secretary of Defense Dick Cheney canceled in 1991 because it was overbudget and not meeting its technological goals.

The flying-wing, carrier-based stealth-strike airplane was being developed under a tightly classified but not-quite-black program. The jet was only 11 months from first flight, and

nobody has ever disclosed what happened to the partly built prototypes. If one of them had been completed and tested in a revived black program, most likely in the early 1990s, it could have pointed the way toward the F-117 replacement that Richelson suspects is flying now. Unlike the other stealth aircraft, an operational A-12 descendant would combine stealth ground-attack capability with the ability to shoot back at enemy fighters, packing a pair of anti-radar missiles and two AIM-120 air-to-air missiles.

PROVIDING ON-DEMAND WORLDWIDE ATTACK

Lastly, there's Aurora. The name itself is mysterious, evoking something you may or may not have seen. This code name leaked out of an unclassified budget document back in 1985. Such a vehicle—a ramjet-powered reconnaissance and strike aircraft capable of flying at least five times the speed of sound and deploying anywhere in the

world in a matter of hours—has been high on the government's wish list. Aurora is certainly possible. The basic propulsion unit, the ramjet, is no more than a tapered tube with a fuel injector and burner in the middle and a thrust nozzle at the end. Basic ramjet-powered missiles have topped Mach 6. A wealth of aerodynamic data and test flights suggest that a wedge-shaped aircraft would work at these speeds.

I first heard about this kind of program in the mid-1980s, and the first public hint of the project popped up in 1988, when the *New York Times* reported that the Air Force was developing a spyplane capable of better than Mach 5—nearly twice as fast as the SR-71, then the world's fastest airplane.

Two years later, the Blackbird was retired. In June 1991, the first in a series of unexplained shock waves rolled across the Los Angeles basin, rattling doors and windows and making people think of earthquakes. But they were not earthquakes, and the military adamantly denied that any of its vehicles caused the booms. In May of this year, I consulted with Dom Maglieri, an ex-NASA sonic-boom expert who has played a key

(CONTINUED ON PAGE 115)

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**THE NEW SCIENCE OF
INVISIBILITY**
P.80

POPULAR SCIENCE

THE
FUTURE
NOW

**GADGET
OF THE MONTH**



P.23

The Ultimate
Wi-Fi Device

REVEALED:

**THE TOP-SECRET
WARPLANES OF
AREA 51** P.72



CODE NAME: AURORA
This long-rumored
bomber could top Mach 6.

NEW WORLD RECORD!
**THE FASTEST MAN ON TWO
PEDALS** P.16



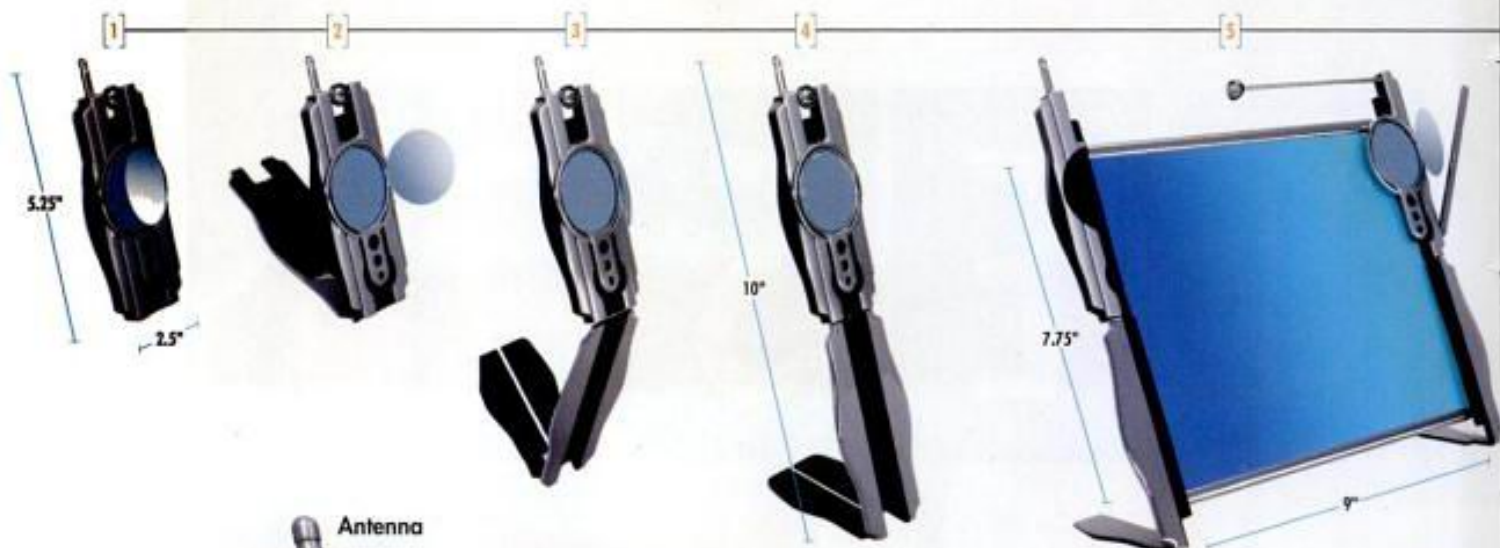
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**THE UNIVERSE IS
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Mind-Blowing Discoveries From
The **POPSCI Brilliant 10** P.55



Antenna

Keyboard projector

Battery Blues

Whatever the super PDA looks like by 2010, everything in it will be smaller, faster and stronger. Everything, that is, but the battery. It'll be incrementally better than today's standard battery. You'll have to wait another five years for a real pocket-size power revolution. That's when membrane technology should increase the surface-area-to-volume ratio of fuel cells enough to make them practical for mobile use. And better fuel-flow management will help solve one of fuel cells' most stubborn problems: handling variable power demands. Another possible solution is combining a fuel cell with a battery. The battery would supply power to the device, while the fuel cell would keep the battery juiced.



COMPACT MIDSIZE

Open up the handheld-mode display panel [1] to turn the PDA into a videophone [2]. Unfurl the desktop-mode display [3, 4, 5]: Polymers along the flexible OLED edges stiffen when an electric charge is applied, keeping it open and flat.

PERSONAL TECH



SPEAK 'N' SPELL

The versatile command-and-control panel varies with communicator function. A stylus and handwriting-recognition software allow the user to write and wirelessly send e-notes; the stylus doubles as a touchpointer for the interactive display.

No. 1

This PDA Is a Real Pocket PC

>> The handheld "smart communicator" will have the memory and processing power of today's best desktop computers, and it'll display on any nearby screen. The virtual laptop is pocket-size.

Call it the smart communicator. In a few years, the functions in today's personal digital assistant (PDA)—notebook, to-do list, calendar, contacts—will be the least of it. Thanks to a variant of Moore's Law that says data-storage density doubles every 18 months, tomorrow's smart communicator will hold 250GB—enough to store 55 movies.

Indeed, video—both viewing and recording—will be a killer app. One reason: "There will be phenomenal leaps forward in display technology," says Hank Nothhaft, chairman and CEO of Danger Labs, maker of the SideKick PDA. Say good-bye to your PDA's power-greedy liquid crystal display (LCD). Say hello to the smart communicator's energy-efficient, organic light-emitting diode (OLED) display. OLEDs use organic materials that emit light when electrically charged, so there's no need for a backlight. Already found in some cellphones, OLEDs offer a wider viewing angle and faster refresh rate than LCDs, improving the look of everything from games to business graphics.

Another leap: high-speed wireless connectivity. As data-transfer speeds of 400 Kbps become standard, high-quality streaming video will become a reality. The potential of Bluetooth, a wireless technology with a range of about 30 feet, will also bloom on the smart communicator, giving it the ability to connect to remote keyboards and displays. "You'll carry your whole life in your PDA," says Scott Summit, designer of the award-winning Tapwave Zodiac PDA. "And any device next to it—a computer, a TV—will reconfigure to run from it." Business travelers will be able to use it with screen-and-keyboard combos in hotel rooms and airports, where the device's expanded mode, complete with projected keyboard, might be awkward.

The smart communicator will have its own nervous system: sensors that assess the outside world and adjust the device's behavior accordingly. A built-in RFID (radio-frequency identification) reader will pick up data stored on RFID tags in nearby objects, so the PDA will automatically embed identification labels in the photos it takes. The on-board eye scanner will let you navigate pages with a mere glance at the menu bar. Light, heat and motion sensors will enable the device to know whether it's in your pocket or your hand, and pump up its cellphone's ring tone if needed. A tilt sensor will trigger the display to shift between portrait and landscape mode, and it'll offer finger-free scrolling. The microphone will measure ambient noise and adjust the volume to compensate in a loud restaurant. The GPS will detect when you're nearing home, and the communicator will signal ahead to turn on the heat or AC. Once you arrive, the Bluetooth network will automatically synchronize data between your communicator and your PC.

With so much personal information packed in it, you'd think your smart communicator would be worth 10 times its weight in platinum to an identity thief. And it would be, if not for the combination of software encryption and biometrics it will employ to keep criminals out. If you lose it, the thumbprint-sensing power switch will cause the screen to display a message asking the finder to return it to you. It'll also secretly transmit its location via any available wireless network, so you can track it on a Web-based map. Don't be sur-

SPACE HOTEL! WE TURN THE ISS INTO A ZERO-G HILTON

POPULAR Science

What's Next

5 MIND-BENDING CONCEPTS
FROM THE NEAR FUTURE

Super PDAs
Specto-Bots
Brain Spas
Cloning Kits
Self-fixing Cars



PLUS

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SATURN UNVEILED

It may not be faster or cheaper, but the spacecraft headed for Saturn aims to be *better* than anything we've flung across the solar system.
by DAWN STOVER

SEVEN YEARS AGO, the largest and most expensive interplanetary probe ever built blasted off from Cape Canaveral. It was loaded with 12 advanced scientific instruments, 72 pounds of plutonium to power them, and a capsule destined to be jettisoned toward the only other object in our solar system protected by a nitrogen-based atmosphere. After launch, the spacecraft began its voyage through the void of space and was promptly forgotten by all but a few scientists and space enthusiasts.

Since then NASA has launched the International Space Station, a Mars orbiter

Text continues on page 72 >>

CASSINI REVEALED:
TURN PAGE FOR FOLD-OUT



October 15, 1997: A Titan 4-B rocket lifts the Cassini-Huygens mission from Cape Canaveral.

April 26, 1998: Cassini whips around Venus, getting a boost in speed from the planet's gravitational tug.

June 24, 1999: Cassini swings past Venus again for a second boost.

August 18, 1999: Cassini flies 727 miles above Earth during its third gravity assist. This push rockets Cassini toward the outer solar system.

THE RING LEADER

→ Though Saturn is arguably the most spectacular body in the night sky, a gas giant adorned with brilliant rings and more than 30 moons of all sizes, we know surprisingly little about it.

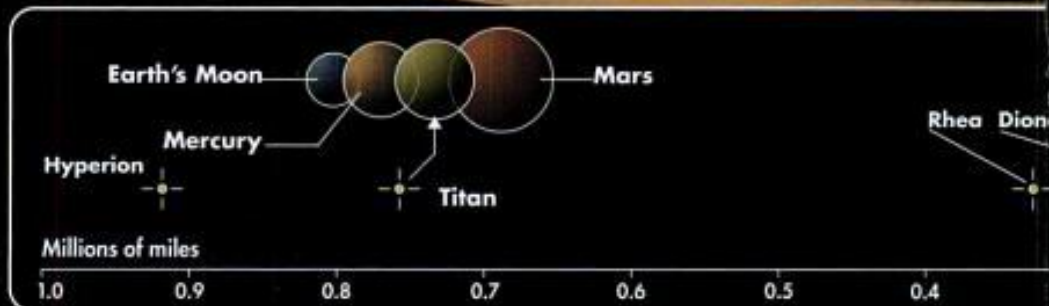
Despite a few brief flybys by '70s-era spacecraft (Pioneer 11, Voyagers 1 and 2), the planet remains a distant, mysterious glow.

All this will change beginning this month as Cassini—the largest, most expensive and complex interplanetary spacecraft ever launched—begins a tour of Saturn and its moons. Cassini will study Saturn for four years instead of its predecessors' mere days, equipped with instruments at least 10 times as sensitive.

The heart of the tour begins July 1, when Cassini's main engine will fire for 95 minutes to slow down the spacecraft and insert it into Saturnian orbit. "This is probably the riskiest event in the entire mission, not counting launch," says Bob Mitchell, Cassini's program manager. Though the detailed orbital plan hasn't yet been set, the next four years should bring 74 orbits around Saturn, with dozens of flybys of its icy moons, and, if all goes well, enough discoveries to hold us over until Cassini's eventual successor arrives.

MARCHING THROUGH THE MOONS

Saturn has 31 known moons, some as small as 12.5 miles across, and Cassini will probably discover more on its mission. **TITAN** is Saturn's largest moon—it's nearly as large as Mars—and the only object in the solar system other than Earth with a nitrogen-based atmosphere. Scientists believe it may also be the only other object dotted with liquid oceans on its surface. Another six midsize moons—**MIMAS**, **ENCELADUS**, **TETHYS**, **DIONE**, **RHEA** and **IAPETUS** (2.2 million miles from Saturn, not shown)—are probably made of water ice, though scientists need to get a closer look to be sure. **HYPERION** is the largest irregularly shaped moon. Jean Dominique Cassini and Christian Huygens, the European astronomers for whom the spacecraft and its probe are named, discovered Saturn's five largest moons in the 17th century.

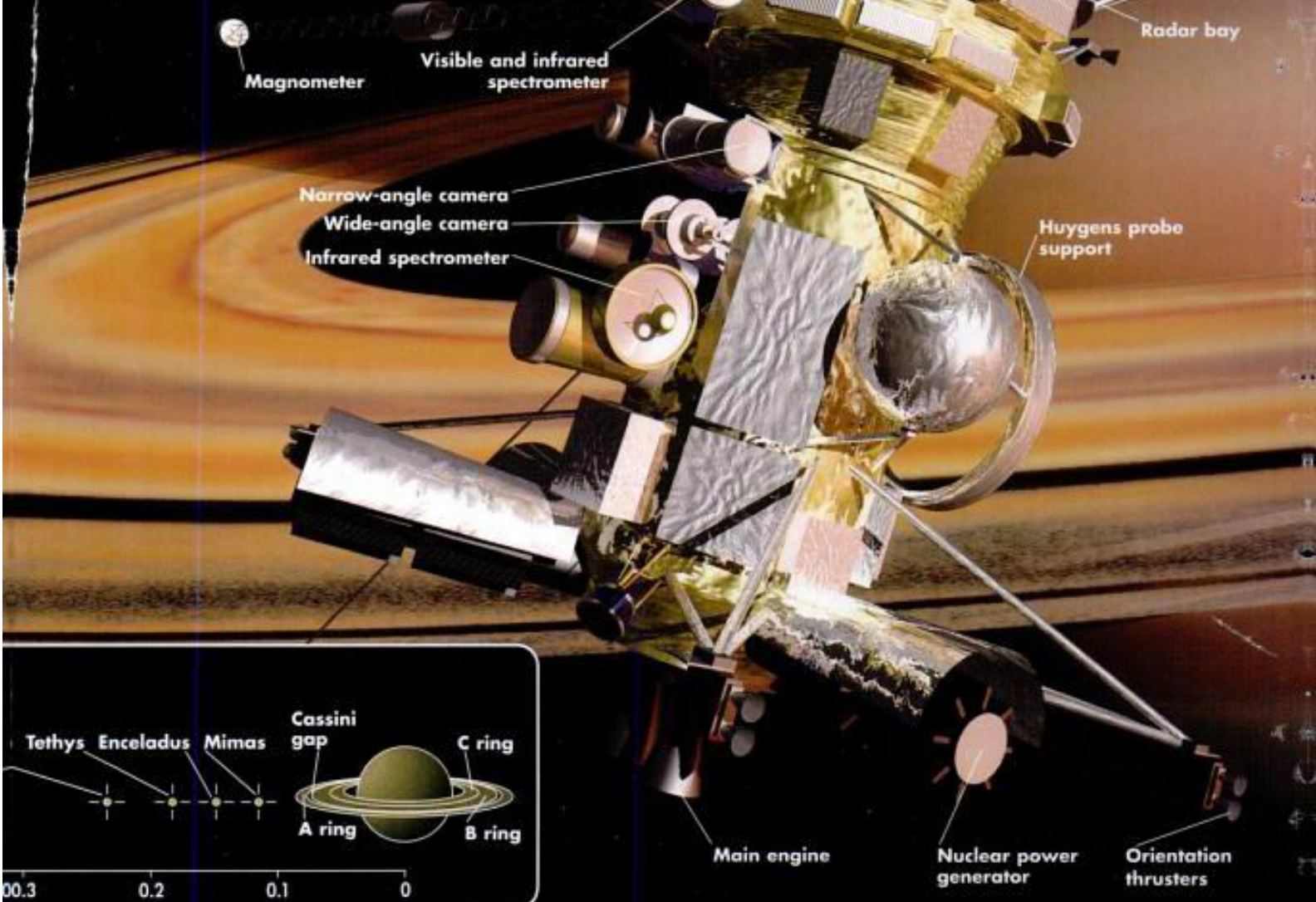


December 30, 2000: In Cassini's fourth and final flyby, Jupiter slings it toward Saturn. During the flyby, Cassini studies Jupiter along with the Galileo spacecraft.



PLANETARY SLINGSHOT

Sending Cassini straight to Saturn would have required too much fuel. Instead, Cassini exploited the slingshot effect as it passed by Venus (twice), Earth and Jupiter. When a craft passes around a planet, the planet's motion and mass whip the craft forward.



INSET INFOGRAPHICS BY JASON LEE

June 11, 2004: Cassini zips past Phoebe, a distant moon orbiting Saturn. Tiny Phoebe may be a captured asteroid.

July 1, 2004: Cassini fires its engine to slow down, crosses the rings, and begins to orbit Saturn.

December 24, 2004: Cassini releases the 700-pound Huygens probe, which drifts toward the moon Titan for the next 22 days.

January 14, 2005: Huygens enters Titan's atmosphere. If all goes well, the probe will land 2.5 hours later.

YOUNG RINGS, OR RECYCL

Saturn's rings, the planet's dominant feature, are its most puzzling. Their large size and bright colors make the rings young by planetary standards: They are only a few millions of years old. This might be because the rings are constantly recycled by moonlets that accrete dust, then knock it loose. Scientists will use Cassini to learn more about how the solar system was formed and how much like Saturn's swirled around 4.5 billion years ago, eventually coalescing into the planet we see today.

Huygens probe



THE BULK OF THE MISSION

Cassini is a monster, a spacecraft the size of a school bus though immeasurably more complex. It stands more than 22 feet high, weighs more than six tons, holds seven miles of cabling and relies on more than 20,000 wire connections. This massive shell houses Cassini's 12 power-hungry scientific instruments and associated communications equipment. There isn't a lot of sunlight at twice the distance from the Sun as Jupiter, so Cassini relies on plutonium for power. Three radioisotope thermoelectric generators convert heat from the decay of 72 pounds of plutonium into electricity, then use the electricity to power the craft. Once the instruments—including cameras, cloud-penetrating radar to map the surface of Titan, and spectrometers to study the chemical composition of surfaces, atmospheres and rings—collect data, three antennas will send up to 249 kilobits of it per second back to Earth.

ED?

are also one of
ness imply that
only a few tens
se their material
mulate gas and
he rings to learn
ed. Disks of gas
d a nascent sun
to planets.

Huygens probe
enters Titan's
atmosphere at a
speed of more
than 13,000 mph

When the probe slows
down to 900 mph, the
main chute deploys

The front
heat shield
is jettisoned,
and scientific
measure-
ments begin

About 15
minutes later,
the main chute is
released, and a
smaller drogue
chute deploys

SPLASHDOWN ON TITAN

On Christmas Eve 2004, the Cassini orbiter will eject a 700-pound daughter ship named Huygens and send it toward Titan, Saturn's largest moon and one of the most mysterious bodies in the solar system. Titan is enshrouded in a methane-and-nitrogen atmosphere five times as dense as Earth's. Scientists think that some of the methane might condense, creating clouds that rain liquid hydrocarbons at -180°C onto Titan's surface. If true, pools or even oceans of the liquid might pockmark the landscape. Huygens will drop through the atmosphere as cameras take pictures that are expected to reveal an alien landscape unlike anything we've ever seen before.

July 1, 2008: Running out of propellant and electrical power, Cassini ends its primary mission.

The probe
may survive
the landing,
floating
if on liquid,
and continue
to transmit
data

Within a few years, scenes like these will become commonplace, thanks to a revolutionary piece of portable technology: your cellular phone. Well, not your current cellphone. But the technology of the cellular phone—and the role that it plays in our lives—will be utterly transformed by something called 3G, or the so-called third generation of wireless telecommunications devices (after analog and digital phones). And if you think you know what it means to own and use a cellphone, you may have to clear your head. The 3G generation will come in a variety of shapes, sizes, and services, some of which hardly resemble the portable gabbers we know and love (or simply tolerate) today.

What exactly will 3G cellular mean? According to the standards already laid out by the International Telecommunication Union, 3G mobile devices will provide wire-line voice quality and very fast data rates for a wireless device—a minimum of 144Kbps, or roughly three times what most of us can squeeze out of a regular phone line with a 56Kbps modem. Those high data rates are expected to make practical a variety of audio and video services, such as music downloads, Internet radio, videoconferencing, and video e-mail. In addition to these functions, which will be provided via the new 3G networks, the pocket-sized devices we carry around will be packed with perks, such as color displays, removable storage media, and text-to-speech capabilities.

As with the changeover from first-generation analog cellular technology to second-generation digital technology, 3G's ramp-up from possibilities to realities will take some time. The first digital cellular phones of the early 1990s were large by today's standards and did just one thing: make or receive calls. Analog cellular modem cards did let you browse the Web with your laptop. But the phones themselves merely acted as dumb phone jacks. Today, you can purchase phones that are barely larger than chewing gum packs, can store hundreds of numbers, browse the Web, organize your day, and play

MP3 music. The first 3G handsets will start out with these capabilities and go from there.

But there's work to be done first. The foundation for these new 3G handsets and services lies in the networks. Service providers, such as AT&T Wireless and Sprint PCS, need to upgrade their existing cellular networks to support higher data rates, locate individual users, and prioritize packets of information so they can move from place to place much faster. When the first 3G services roll out later this year from Sprint PCS, you'll be able to browse the Web or receive various information services at speeds up to 144Kbps, or up to 10 times faster than the carrier's current capabilities. At busy times of day, you could expect speeds of perhaps 70- to 80Kbps. Sprint PCS says its network, which will use the cdma2000 (code-division multiple access) standard, should reach top speeds of 307Kbps by 2002, and go as high as 3- to 5Mbps by late 2003. At these high speeds you could listen to an audio clip or view a movie trailer streamed in real time from a Web site. And your connection is always "on"—you're connected at the press of a button without any waiting.

Sprint PCS, of course, isn't the only wireless carrier that will supply 3G service. AT&T Wireless is building a new wireless network based on the GSM (Global System for Mobile communication) standard, which should begin operating in 2002 and gradually move in three steps from speeds of 115Kbps to 2Mbps. The final standard will be UMTS (Universal Mobile Telecommunications System, which some providers call Wideband Code-Division Multiple Access), which will deliver speeds of 2Mbps. To benefit from each of these speed bumps as they become available, whether from AT&T or Sprint or someone else, you'll need a new 3G phone. And with color displays on the outside and lots of gadgetry inside, such phones may not come as cheaply as cellphones do today.

In addition to increasing the raw speed of their data deliveries, 3G car-



sanyo 

The Multi-Communicator looks and works like a regular cellphone when closed. But open it and it becomes a videoconferencing terminal.

ericsson 

Though designed primarily for voice calls, this palm-size cellphone's color LCD also enables you to view photos.



THE LOOK OF THINGS TO COME

TRY TO CLEAR YOUR MIND of any preconceptions you may have about what a cellphone is. The multifunction devices that will work on next-generation 3G networks will come in a variety of shapes and sizes.

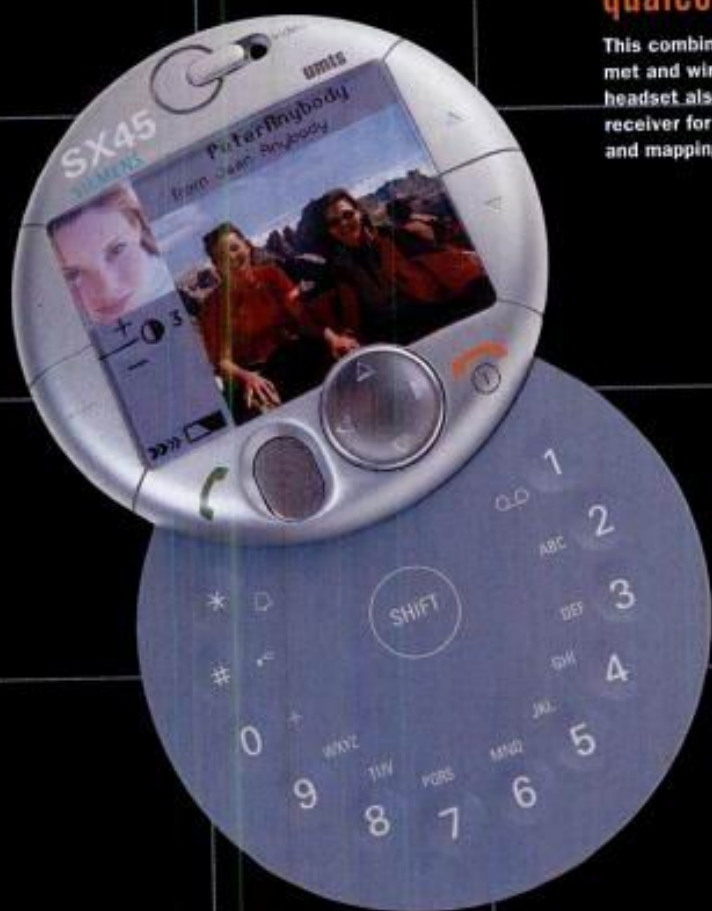
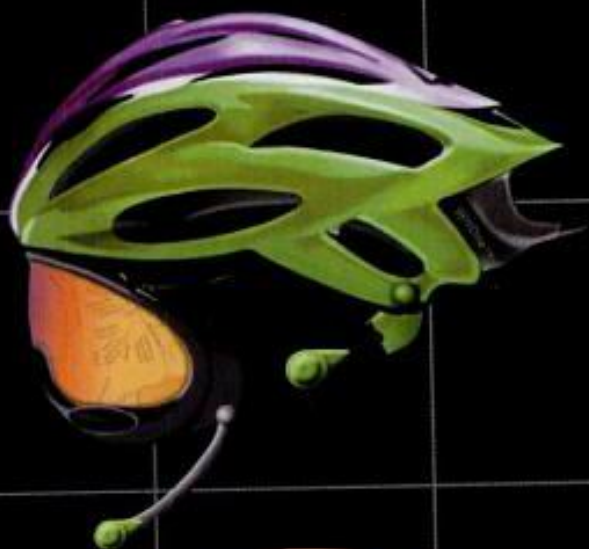


ericsson

Built for full-time use as a PDA, Ericsson's RX 1 doubles as a cellphone when you remove its wireless earpiece.

qualcomm

This combination bike helmet and wireless phone headset also features a GPS receiver for accurate routing and mapping information.



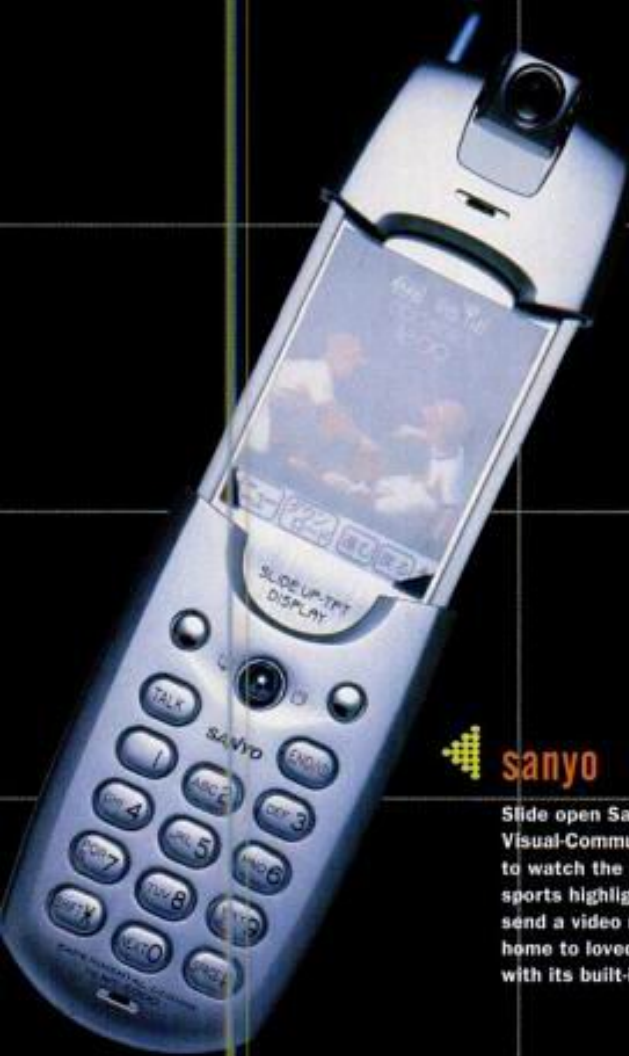
fujitsu

Rugged enough for the most hearty handling, Fujitsu's combination PDA-videophone makes its large color display the focal point.



siemens

Hidden behind the SX45 videophone's sleek surface lies a surprisingly old-fashioned dial-pad design.



Slide open Sanyo's Visual-Communicator to watch the latest sports highlights, or send a video message home to loved ones with its built-in camera.

A CELLPHONE TIMELINE

FROM BASIC VOICE service to full-motion video, cellphones have come a long way.

1st Generation 1980s

Bandwidth Required 3Kbps

- Connection to laptop

2nd Generation 1990s

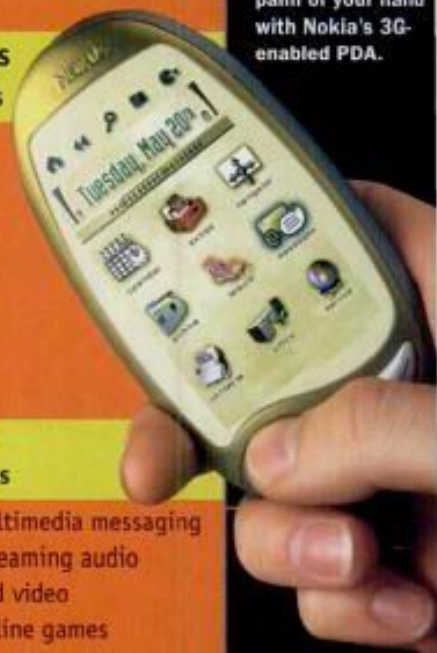
Bandwidth Required 9.6Kbps

- Messaging
- Basic Web browsing
- E-mail
- E-commerce
- Telemetry
- Vertical solutions
- Vehicle location

3rd Generation 2001

Bandwidth Required 384Kbps

- Full Web browsing
- E-mail with attachments
- Richer e-commerce
- Corporate intranet
- Multimedia messaging
- Streaming audio and video
- Online games
- Video telephony
- Music download



nokia

Put your e-mail access, Web browsing, calendar, and contacts literally in the palm of your hand with Nokia's 3G-enabled PDA.

riers in the United States are working on a means of prioritizing certain types of data, such as audio and video. Prioritizing seeks to properly weight the importance of speed to a given application—while you might be willing to wait a couple of extra seconds for an Excel spreadsheet to download, for example, any delays in transmitting a video clip can make for annoying viewing. A reliable method of prioritizing data packets will also enable carriers to split up voice calls into packets of data, instead of dedicating a full channel to each call. With packeted voice calls, the carriers will be able to handle at least twice the volume of calls, which will mean fewer times when you can't place a call due to an overloaded network.

Another key network technology of 3G will be its ability to pinpoint your location to within 50 meters. This capability was mandated by the FCC so that 911 operators can dispatch emergency services to callers who don't know where they are. But armed with

your location, carriers could also offer all sorts of location-based services, including driving directions, a list of the closest gas stations, and coupons for nearby retailers. There will, no doubt, be privacy issues associated with this aspect of 3G, but carriers are confident that by using an opt-in policy—in which you choose when or where or with whom to share location data—you will have some control over who knows where you are.

So what will your new 3G phone look like? Perhaps not like a phone at all. In fact, you'll likely have several 3G-enabled products eventually—a phone, an organizer, a game machine, a Web tablet, and maybe even your car. Unlike today's cellphones, many 3G devices will have a broad range of capabilities, including MPEG-4 video and MP3 audio decoding, voice recognition, and Bluetooth personal area networking—making them more akin to computers than phones. And the desire for bigger screens on these more versatile Web and video devices is apt

to grow, so not all of them will be as small as your current cellphone either.

One thing won't change: You'll still need to mate your 3G phone with a compatible 3G service, since not all carriers will use the same underlying network standards to achieve their goals. (Initially, 3G devices will work on the cdma2000 and UMTS network protocols.) As always, you'll need to pay attention to the coverage map of your 3G carrier, as it will expand over time. Eventually, there will be combination phones that will work on different types of 3G networks, just as some multi-mode phones today can handle calls over analog, digital, and PCS systems. And with Europe and Asia also moving toward 3G systems, truly global phones may become more commonplace as well.

But first, carriers and phone makers will need to produce on 3G's more basic promises, which have been talked about for more than a decade now. That, finally, should happen soon. Then it's your call. ▶



Every fall, hundreds of thousands of technology-obsessed visitors descend on Las Vegas to turn the gamblers' paradise into a 24/7 Nerd World.

By John R. Quain



You've Got Home Networking

INTERNET APPLIANCES were in force at Comdex, but foremost among them was the Gateway Connected TouchPad with Instant AOL service. Intended for the kitchen or den, the \$599 device not only offers one-touch access to America Online's services but also can be used to control all the other computing devices in your home.

Cutting the Cables

WHAT DO YOU GET when you put a camera and a wireless modem in a pen? The Ericsson Chatpen, a stylus that magically makes handwritten notes appear on a computer or cellphone. Expected later this year for less than \$200, the pen uses special paper and Bluetooth wireless technology. The Chatpen will join other products using the short-distance (under 30 feet) wireless technology, including a new line of Compaq notebooks.

Write-on PC

SONY'S TABLET VAIO N80 gives the personal computer a new twist with a tilting, crystal-clear, 18-inch LCD screen you can write on like a tablet with an electromagnetic pen. Sony has developed special Windows software that provides a dynamic rotating view of all your pictures and documents. Expect to see the N80 later this year for around \$3,200.





CASIO
Cassiopeia



HANDSPRING
Visor



MICROSOFT
Stinger



KYOCERA
Smartphone

Not Your Father's Notebook

TOSHIBA TOUTED several head-turning designs, including this ultrathin collapsible notebook computer. Still in the design phase, the Toshiba laptop features a



wafer-thin screen and a keyboard that slips back and

up into the computer. For those who would rather read than type, Toshiba also inspired gadget envy with its vision of the next-generation of folding e-books (inset).



Cellphone or PDA?

CASIO and Handspring introduced add-ons that turn their PDAs into cellphones. Casio's battery pack doubles as a TDMA cellphone, while Handspring's GSM \$299 Visor Phone clips into the Springboard expansion slot on its Palm OS-based handhelds.

Meanwhile, cellphones were also being turned into PDAs. Kyocera revealed its forthcoming Palm OS-based cell. It has a slimmed-down look but offers full-fledged organizer functions. Ericsson took the wraps off its sleek R380 World Smartphone, which has a flip-down dial pad that conceals a Web browser. And Microsoft's not-so-secret prototype Stinger cellphone was formally revealed; commercial versions are expected late next year.



Tunes and Pictures

THE DIGITAL-MUSIC CRAZE inspired a welter of MP3 players at Comdex. Standouts were from Samsung, including the Multi Yepp—a prototype that also takes digital still pictures and can play MPEG-4 video—and the Baby Yepp (below), a locket-style music player that holds up to an hour's worth of music and goes on sale this year for about \$150.



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WHAT'S
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Wireless Web Wonders

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THAT SET
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OF THE CIA
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the Super Spies

X-PLANE SHOWDOWN
Which Supersonic Fighter
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By Christopher Miller

Gadget Fetish

Forget form following function. Tomorrow's electronics products are obsessed with their looks.

TAKE ONE PART reality, two parts imagination, and mix. This is the original recipe for producing new products, but now designers must add a healthy dose of entertainment and fashion to make tomorrow's technologies attractive today. No longer can gadgets be just functional—they must be sleek and chic as well. Product has become fashion, says Ravi Sawhney, CEO at RKS Design in Thousand Oaks, California.

Beneath these devices' glossy exteriors, the technology that will make them tick will be wireless radios—Bluetooth, wireless LAN, cellular—for connecting to data services at home and on the road. Anywhere, anytime communications is our future.

The likelihood that you will ever see these exact devices in production is slim. But you will carry, wear, or display products like them soon. Our future, it appears, looks good.

iRock Your World

DEVICE: iRadio

DESIGNER: Pentagram

SUBTLE DESIGN CUES from classic AM radios accent the concept receiver of tomorrow: the iRadio. At your disposal would be every radio station in the world—including those broadcast solely on the Internet. Physically plug in the iRadio or establish a wireless Bluetooth link to your home's broadband Internet connection, and you're set. Tunes, talk, and news emanate from the ultrathin, clear speaker developed by THX in England.

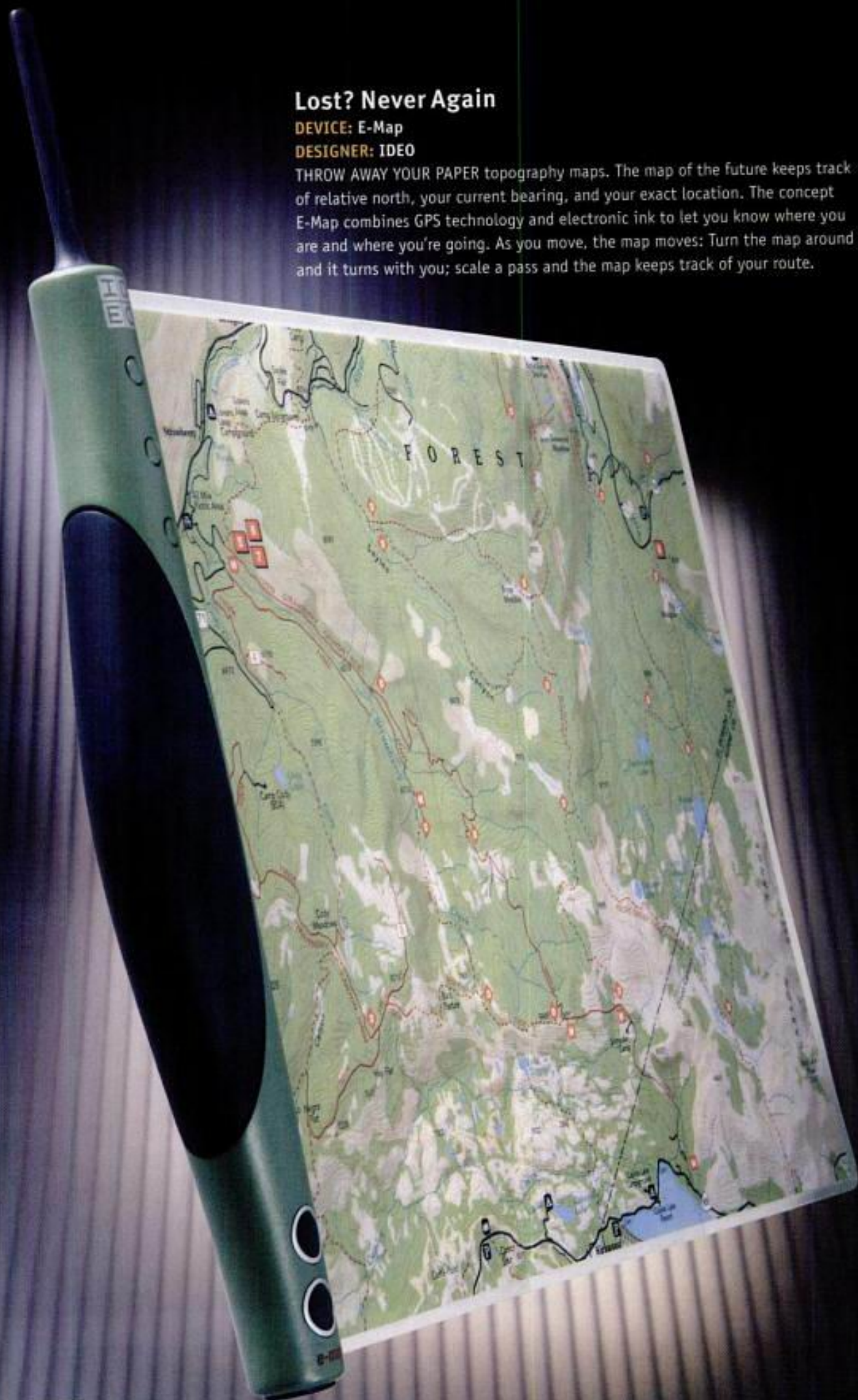


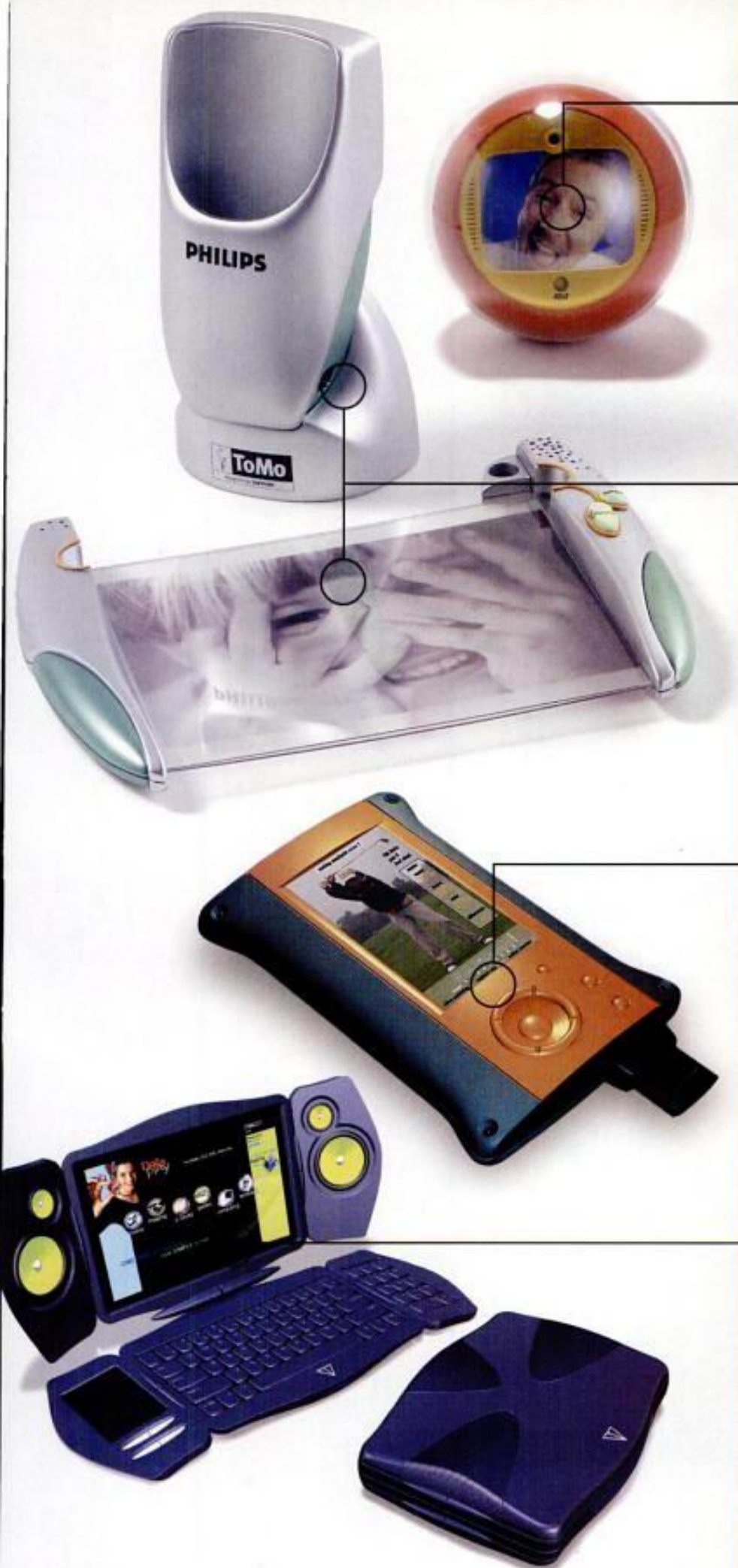
Lost? Never Again

DEVICE: E-Map

DESIGNER: IDEO

THROW AWAY YOUR PAPER topography maps. The map of the future keeps track of relative north, your current bearing, and your exact location. The concept E-Map combines GPS technology and electronic ink to let you know where you are and where you're going. As you move, the map moves: Turn the map around and it turns with you; scale a pass and the map keeps track of your route.





On the Ball

DEVICE: Kid-Ball

DESIGNER: Frog for AT&T

AS TELECOMMUTING gains popularity, videoconferencing phones may come to replace today's ubiquitous cordless handsets. This basketball-sized "Kid-Ball" wireless videophone concept was designed with children in mind, but multiple balls can be used for videoconferencing as well. A video screen, camera, speaker, and microphone fit inside the ball. Dialing is as easy as saying the number.

Web in the Pocket

DEVICE: Fiore

DESIGNER: Chen Sapirstein

YOUR PDA OF THE future will also be an MP3 player, Web browser, and videoconferencing unit. Fiore has a flexible, retractable screen. When open, a camera mounted on the upper right side captures full-motion video as well as digital stills. Bluetooth connects you to the Web via cellphone or home broadband service. Or, connect the old-fashioned way—that is, plug it in. Holder-charger is shown above.

Go Golfing

DEVICE: Golf Buddy

DESIGNER: IDEO

YOUR GOLF PARTNER may still laugh at your slice, but your Golf Buddy won't. This prototype palm-size advisor comes with built-in GPS receiver, camera, and sensors, which enable it to monitor your stance through your swing. You can even have your swing analyzed right on the course. On the fairway or in a sand trap, the Buddy coaches you through tough spots on the links.

Paperback Writer

DEVICE: DataPlay Laptop

DESIGNER: Volan Design for DataPlay

IN THE QUEST to make laptops even smaller, DataPlay's design is about the size of a paperback, measuring 5 by 7 by 1 inches. Much like a work of origami, the notebook's detachable track pad, number pad, and speakers fold out. Bluetooth lets you connect to your broadband service, and a built-in cellular modem provides a backup for connecting to the Internet.



Gamer's Delight

DEVICE: Rover

DESIGNER: Ziba Design

MUCH LIKE ADVANCED head-up displays the military uses, the prototype Rover lets you play videogames on the go. Pop a CD-based game in the top of the unit, put on the earphones, and look through the lenses to see the TV monitor. A gyroscope lets you view a 360-degree virtual world by moving your head.

Shop Quick

DEVICE: Cameo

DESIGNER: Herbst Lazar Bell

HATE TRYING ON clothes? In the future, you won't have to. Just input your picture and body measurements into Cameo and hit the mall. See a shirt you like, but not sure if it's really you? Scan the bar code with Cameo, and watch as your body appears as a hologram with the shirt on. A few clicks more brings a matching tie.

Ultimate Flip-Phone

DEVICE: Soho Stick

DESIGNER: DD Studio

THE SOHO STICK is the next-generation cell-phone. Actually, it's a cellphone and a virtual pen. Closed, the Soho Stick writes and scans text. When you're done scribing and scanning, flip open the pen to send your data. An LCD displays who's calling. Finish your day by charging the Stick in its "well."

Totable Tour Guide

DEVICE: Boyfriday

DESIGNER: Lunar Design

FROMMER'S AND LET'S GO travel guides may be extinct in a few years, in favor of a smart device like Boyfriday. Preprogrammed with your get-away itinerary, Boyfriday knows your likes and needs. Don't know where to eat? Just ask Boyfriday. What about that famous exhibit in Spain you wanted to see? Boyfriday shows the way.

Flower Power

DEVICE: Zuzu

DESIGNER: Herbst Lazar Bell

AS DIGITAL DEVICES become as ubiquitous as pens and paperclips, you need a desktop organizer—Zuzu. The prototype Zuzu comes with an MP3 player, digital camera, PDA, and docking station for the devices. Like a plant, Zuzu uses solar energy to recharge its leaf-like attachments. Just don't upgrade the pot with real soil.

Fetish fashion show www.popsci.com

JASON LEE

Power Plants

By Dawn Stover

The world's largest greenhouse holds plants that have changed history.

Humid Tropics Biome

The Humid Tropics Biome features plants from the Oceanic Islands, Malaysia, West Africa, and the Amazon. They include coconut palms, mangroves, nutmeg, rice, passion flowers, rubber, coffee, bananas, mangos, balsa, teak, and cocoa. A waterfall in Amazonia cascades more than 80 feet through a tangle of vines.

The domes are sheltered by pit walls rising 165 feet.

The Link Building between the two greenhouses contains restaurants and educational exhibits.

Louvered vents

Sensors monitor temperature and humidity in the dome. Fans around the base blow in heated air, while nozzles in the roof emit mist. Louvered vents at the top and around the base can be opened for cooling.

Hexagonal insulating "pillows" have three layers of durable, transparent plastic.

INFOGRAPHIC MIKA GRONDAHL

THE PLANT WITH 1,001 uses has found an unlikely home—a surrealistic edifice rising from an abandoned clay pit in southwest England. There, you can find growing a grass used daily by more than half the world's population. Valuable for skyscraper scaffolding, airplane skins, bicycles, musical instruments, furniture, toys, paper, fuel, food, medicines, and even acupuncture needles, it was used to make the first suspension

bridge and the first successful filament for Edison's light bulb. It grows faster than any other plant on Earth, as much as 4 feet in a single day. It's known as "the wood of the poor" in India, "the friend of the people" in China, and "the brother" in Vietnam.

Such trivia about commonplace bamboo finds an enthralled audience at the Eden Project in the Cornwall region of England. "Eden was designed to create a theater,"

says education manager Jo Readman, "to tell the story of plants that changed the world." Plants such as bananas, over which wars have been fought. Plants such as cotton, inspiration for the industrial revolution and the rationale for slavery on two continents. And plants such as coffee and sugar, among the most heavily traded products in the world today.

There are 250,000 species of plants on Earth. The Eden Project

Warm Temperate Biome

The Warm Temperate Biome has plants from the Mediterranean, South Africa, and California. They include lavender, thyme, olives, poppies, grapes, aloe, cotton, and cork oak.

The Roofless Biome

The Roofless Biome is a terraced outdoor area with wild plants native to Cornwall, as well as some from Chilean rainforests and other temperate regions of the world. It includes wheat, barley, indigo, sunflowers, ferns, and a tea garden.

The Amphitheater will be used for theatrical and music shows.

Eden's 25 acres of plantings include trails with various themes. A music trail, for example, has reeds used in woodwind instruments. A beauty trail exhibits plants used in cosmetics and fragrances.

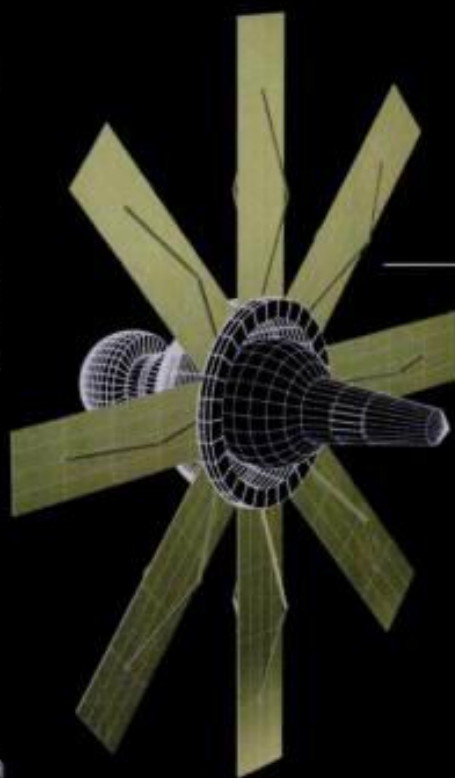
Underground Drainage System

Workers raised the floor of the clay pit by 66 feet to broaden it, and to install a drainage system that prevents water from flooding the pit.



SEVEN SPACE DRIVES

WHILE WORK ON THE ESSENTIAL physics questions is in its earliest stages, that hasn't stopped scientists from thinking about how to harness potential new sources of spacecraft propulsion. Marc Millis of NASA's Glenn Research Center in Cleveland has suggested hypothetical space drives, shown in these *POPULAR SCIENCE* artist's concepts, to spotlight the problems and possibilities of physics yet to be discovered. While these designs would dramatically reduce or eliminate propellant, they would still be limited to travel close to light speed—except perhaps for the Induction Ring on page 50. If just one of these could be made to work, we'd have a breakthrough. But that is one big If.—M.D.

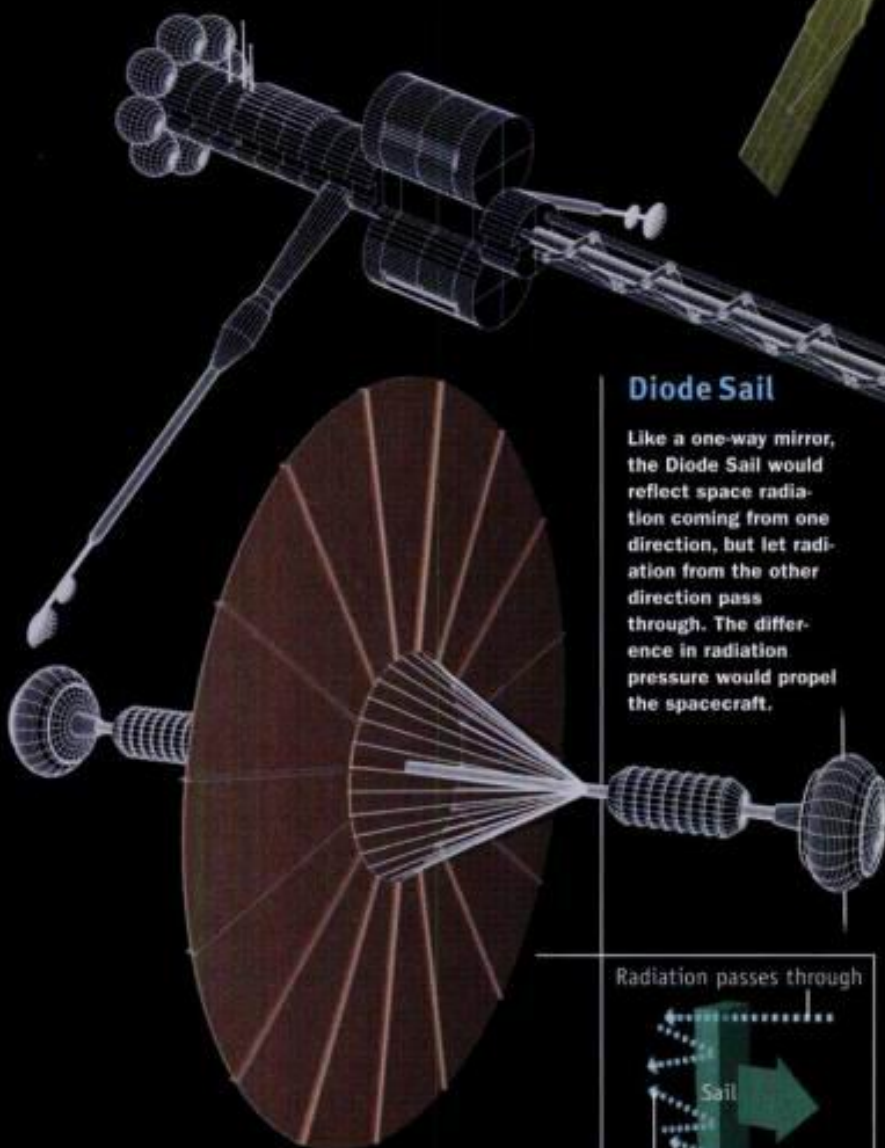


Less radiation pressure



Induction Sail

The pressure of radiation on one side of the Induction Sail is increased by some yet undiscovered means, and the pressure on the other side is lowered. The spacecraft moves toward the low-pressure area.



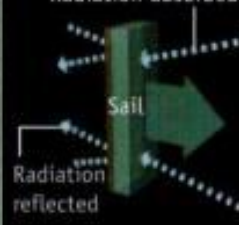
Diode Sail

Like a one-way mirror, the Diode Sail would reflect space radiation coming from one direction, but let radiation from the other direction pass through. The difference in radiation pressure would propel the spacecraft.

Radiation passes through



Radiation absorbed



Differential Sail

Today's rockets zoom along thanks to collisions between the rockets themselves and their propellant. These collisions push the rocket in one direction and the propellant in the other. A hypothetical collision sail would work the same way. Imagine that space has some form of background radiation that is constantly impinging on the spacecraft—perhaps random particles or electromagnetic waves. If you could absorb the collisions in front of the vehicle and reflect the ones behind it, the spacecraft would be pushed ahead.

20,000

21,000

22,000

23,000

24,000

25,000

26,000

Disjunction Drive

One of the most speculative of speculative space drives. The name disjunction refers to the idea of separating the source of a field from that which reacts to the field (normally considered inseparable), resulting in forces on the part that normally reacts to the field.



Induction Ring

An induction ring of negative energy— analogous to negative numbers—would warp space into a sort of bubble around the spacecraft (similar to the effect created by the Bias Drive, below).

Diametric Drive

Today, scientists know that interactions between matter and fields produce force. For instance, gravitational fields accelerate masses—like the apple that supposedly struck Newton. And electric fields accelerate charges. If a spacecraft could create an asymmetric field around itself somehow, then perhaps the field would propel the spacecraft. The Diametric Drive, a generic version of a 1957 "negative mass propulsion" concept, uses the interactions of a positive and negative field to propel the spacecraft.



Bias Drive

The Bias Drive would alter the properties of space itself. For instance, it could reduce normal gravity on one side to produce thrust. Imagine a boat made from a block of wood with one pointed end and the other end indented. The block is floating on water, and you drop detergent behind it. Because soap changes the surface tension of the water, the boat is pushed along.



28,000

29,000

30,000

31,000

32,000

33,000

34,000

SHIP TO SHIP

Sea monster on the port side! Here's how the mightiest ship of our time would look in Nelson's spyglass.

H.M.S. VICTORY

Royal Navy 100-gun First Rate ship of the line, built from 1759 to 1765 and made of wood seasoned for 20 years. First action in 1778. Most famous engagement: under Admiral Horatio Nelson in the Battle of Trafalgar, 1805, when she carried 104 powerful guns. Still floating, fully restored, in Portsmouth, England.

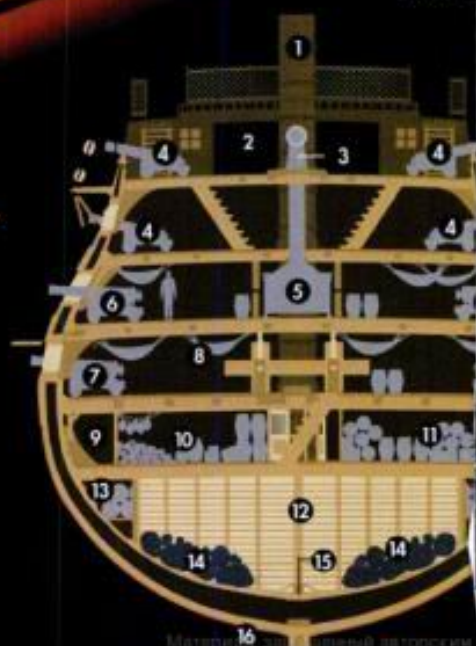
IT TOOK A FOREST Building the Victory required 60 acres worth of trees, most of them oak. Each mast was made from five to seven trees, its pieces secured by iron hoops. The tallest mastwood often came from North America.

HER MAJESTY'S ANATOMY Space was precious, and the ceilings not much higher than a man. Most of the crew slept in hammocks, while the Admiral's cabins featured dining and sitting rooms. Fully loaded, the hold stored several hundred tons of provisions, including 45 tons of biscuits and 50 of beer: The idea was to stock up for long periods at sea, possibly behind blockades. The carpenter's walk, a narrow space between hull and hold, allowed the woodworkers to repair damage from enemy shots. Copper sheathing protected the outer hull from rot, and it increased speed. Though the First Rate was massive, its expansive sails made it, in one historian's words, "not noticeably slower than the rest of the fleet."

FULL SAIL The crew could raise as 34 canvas sails on three masts and boom. The mainmast has 90 holes in it for the ropes.

BATTEN DOWN In heavy weather, gunports were batted down to prevent water from entering the hold.

1. Mainmast
2. Captain's cabin
3. Galley stove chimney
4. 12-pounder gun
5. Galley stove
6. 24-pounder gun
7. 32-pounder gun
8. Crew hammocks
9. Carpenter's walk
10. Carpenter's store
11. Boatswain's store
12. Main hold
13. Gunpowder and weapons store
14. Ballast
15. Limber passage
16. Copper sheathing



A SHORT YET MIGHTY TALL SHIP

Though brief from bow to stern against the three-foot-ball-field length of a *Nimitz* carrier, and displacing a mere 3,500 tons to Reagan's 97,000, the *Victory*'s mainmast stretches as high off the water as the communications gear atop the carrier's "island." It needed the height to accommodate its tremendous expanse of sail.

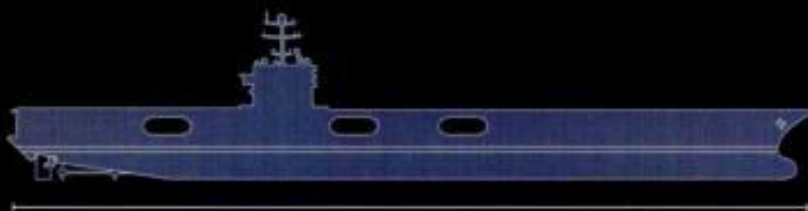


186 feet



52 feet

221 feet



1,092 feet



257 feet

221 feet

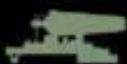
FIREPOWER

19TH-CENTURY ORDNANCE

The Royal Navy didn't have the fastest ships, just the best guns and gunnery crews, which together could get off one shot per gun every 2 minutes. (The "pounder" rating refers to the weight of the cannonballs.)

68 POUNDER

Heavy, slow shot splintered the enemy's deck.



32 POUNDER

Range of a mile, could penetrate 2 feet of oak.



24 POUNDER

Twelve men ran each of the 28 middle-deck guns.



12 POUNDER

Small shot, or grape, for antipersonnel use.



FULLY LOADED

A massive floating gun deck, yet fast.

21ST-CENTURY ORDNANCE

Along with a mighty arsenal of offensive weapons, *Nimitz*-class ships wield a lot of defensive firepower, though no modern Navy can oppose U.S. carriers the way Japanese forces did during WWII. Next to come: unmanned drones.



F/A-18 HORNETS

All-weather attack fighters also aid ship defense.



F-14 TOMCATS

Specialize in ground attacks, could be phased out by '07.



SH-60 SEAHAWKS

Anti-submarine warfare and search and rescue.



S-3B VIKINGS

Multipurpose; electronic warfare and search and rescue.



E-2C HAWKEYES

Tactical battle management, command and control.



EA-6B PROWLERS

Neutralize enemy radar and communications.

DEFENSIVE



RAM SYSTEM

Packs 21 missiles that destroy incoming high-speed targets.



NATO SEA SPARROW MISSILES

Self-defense missiles with a range of 30-plus miles.



A BULBOUS BOW

Redesigned bow provides added stability during flight operations and improved hydrodynamics for better propulsive efficiency.

ould raise as many
n the *Victory*'s
ysprit. One surviv-
tle of Trafalgar
om enemy shot.



DOWN THE HATCHES

seas, the lower
s were closed to
flooding of the
ack.

POOP DECK

QUARTER DECK & FORECASTLE

UPPER DECK

MIDDLE DECK

LOWER DECK

ORLOP DECK

HOLD

CREW

H.M.S. VICTORY

At Trafalgar, the *Victory* had a crew of 819, including 146 Royal Marines, a surgeon and 31 boys.

OFFICERS: 57

||||||| (1 = 10 MEN)

MARINES, SEAMEN AND SERVANTS: 762

U.S.S. RONALD REAGAN

A crew of almost 6,000, including the 2,480-person air wing, includes 526 officers, two lawyers and a dental department 20 deep.

OFFICERS: 160

|||||||

SHIP'S CREW: 3,350

AIR WING: 2,480 (366 OFFICERS)

|||||||

(AIRCRAFT NOT TO SCALE.)

THE BOSS GETS A BETTER VIEW

A redesigned "island" on the Reagan gives the Primary Flight Control group a 270-degree view, enabling better coordination of flight deck operations.

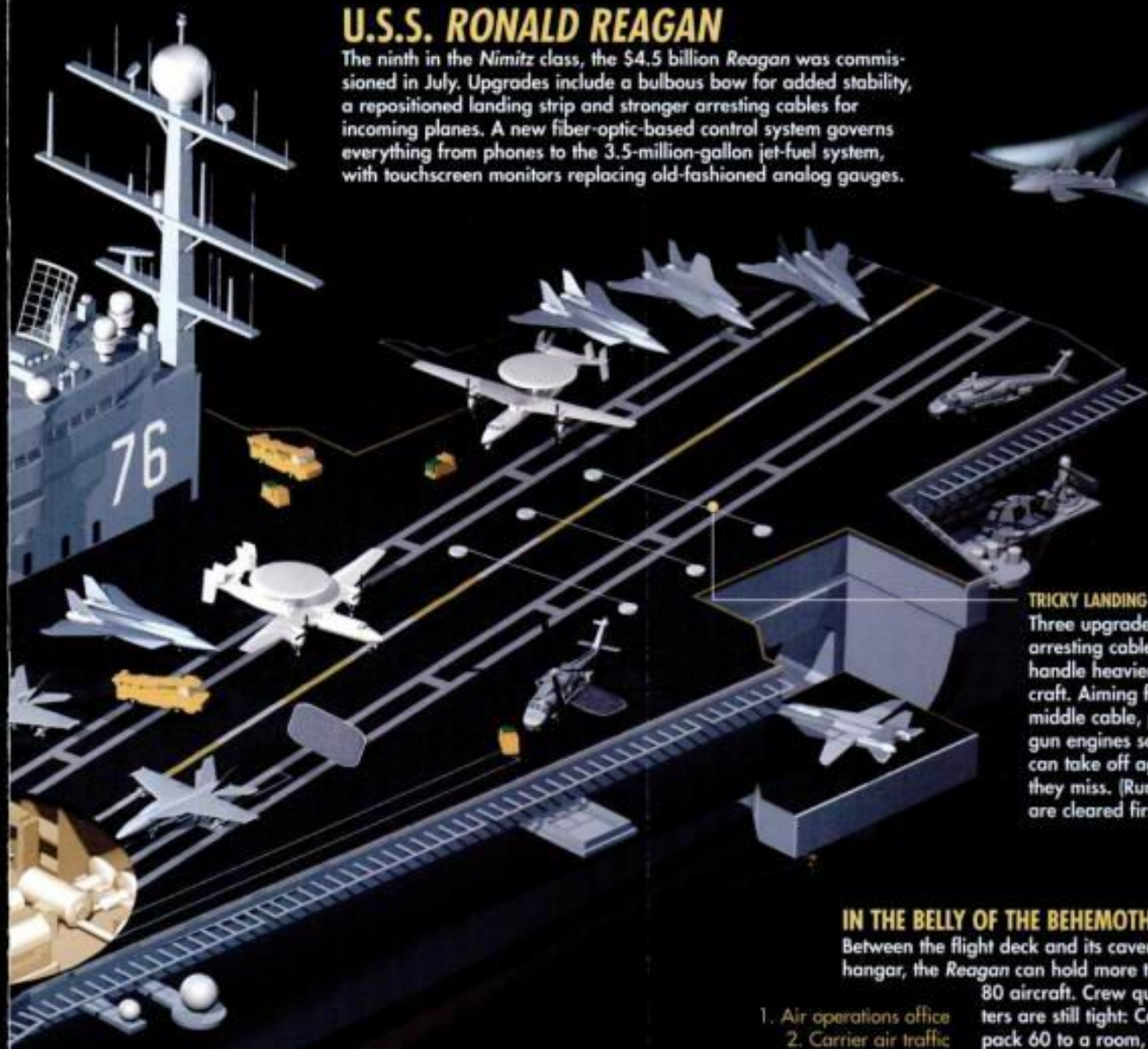
HOW THE FAT CATS FIRE

Four 300-foot-long, steam-powered catapults—called the Fat Cats—accelerate an aircraft to 165 mph in only 3 seconds. A T-bar on the plane's nosegear attaches to a shuttle, which is fired down the line by a huge piston.

Pressure tank

U.S.S. RONALD REAGAN

The ninth in the *Nimitz* class, the \$4.5 billion *Reagan* was commissioned in July. Upgrades include a bulbous bow for added stability, a repositioned landing strip and stronger arresting cables for incoming planes. A new fiber-optic-based control system governs everything from phones to the 3.5-million-gallon jet-fuel system, with touchscreen monitors replacing old-fashioned analog gauges.



TRICKY LANDING

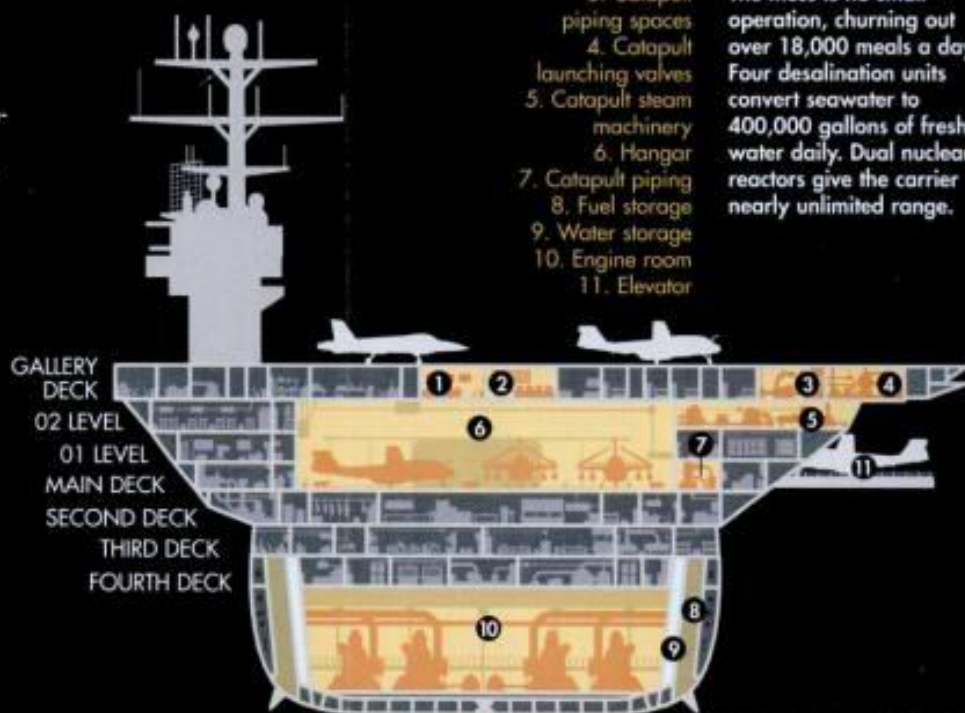
Three upgraded arresting cables handle heavier aircraft. Aiming for the middle cable, pilots gun engines so they can take off again if they miss. (Runways are cleared first.)

DECK REDIRECTED Shifting the orientation of the landing area less than 1 degree to port allows for simultaneous takeoffs and landings.

IN THE BELLY OF THE BEHEMOTH

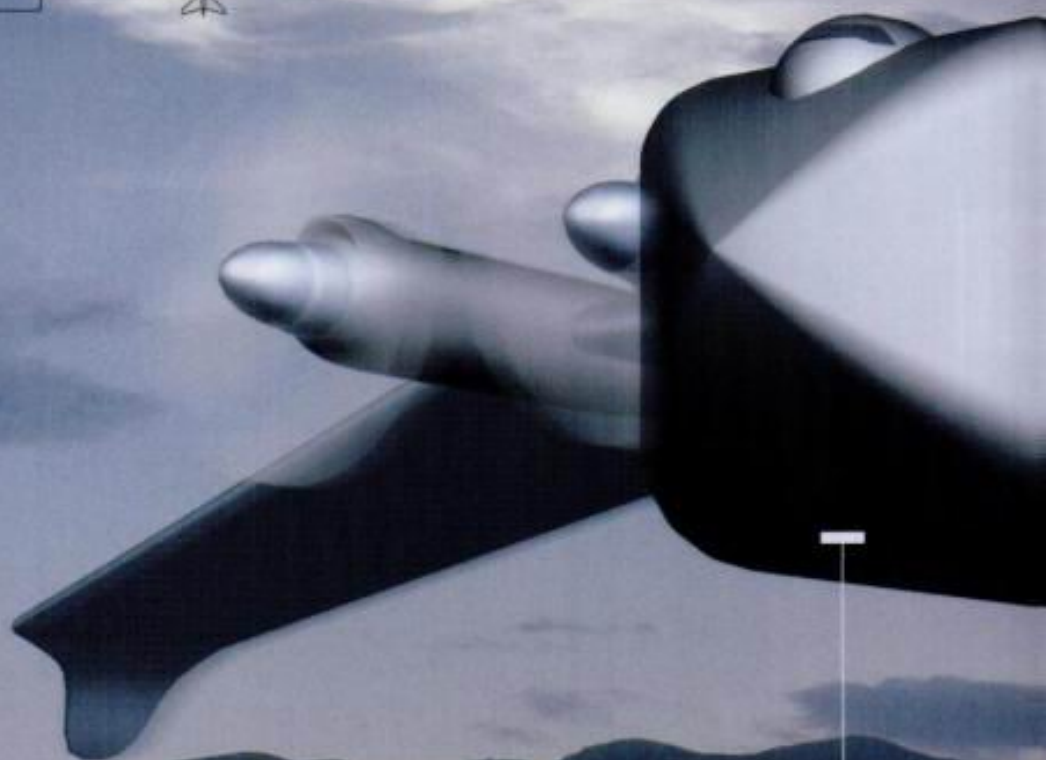
Between the flight deck and its cavernous hangar, the *Reagan* can hold more than 80 aircraft. Crew quarters are still tight: Carriers pack 60 to a room, with bunks stacked three high. The mess is no small operation, churning out over 18,000 meals a day. Four desalination units convert seawater to 400,000 gallons of fresh water daily. Dual nuclear reactors give the carrier nearly unlimited range.

1. Air operations office
2. Carrier air traffic control center
3. Catapult piping spaces
4. Catapult launching valves
5. Catapult steam machinery
6. Hangar
7. Catapult piping
8. Fuel storage
9. Water storage
10. Engine room
11. Elevator



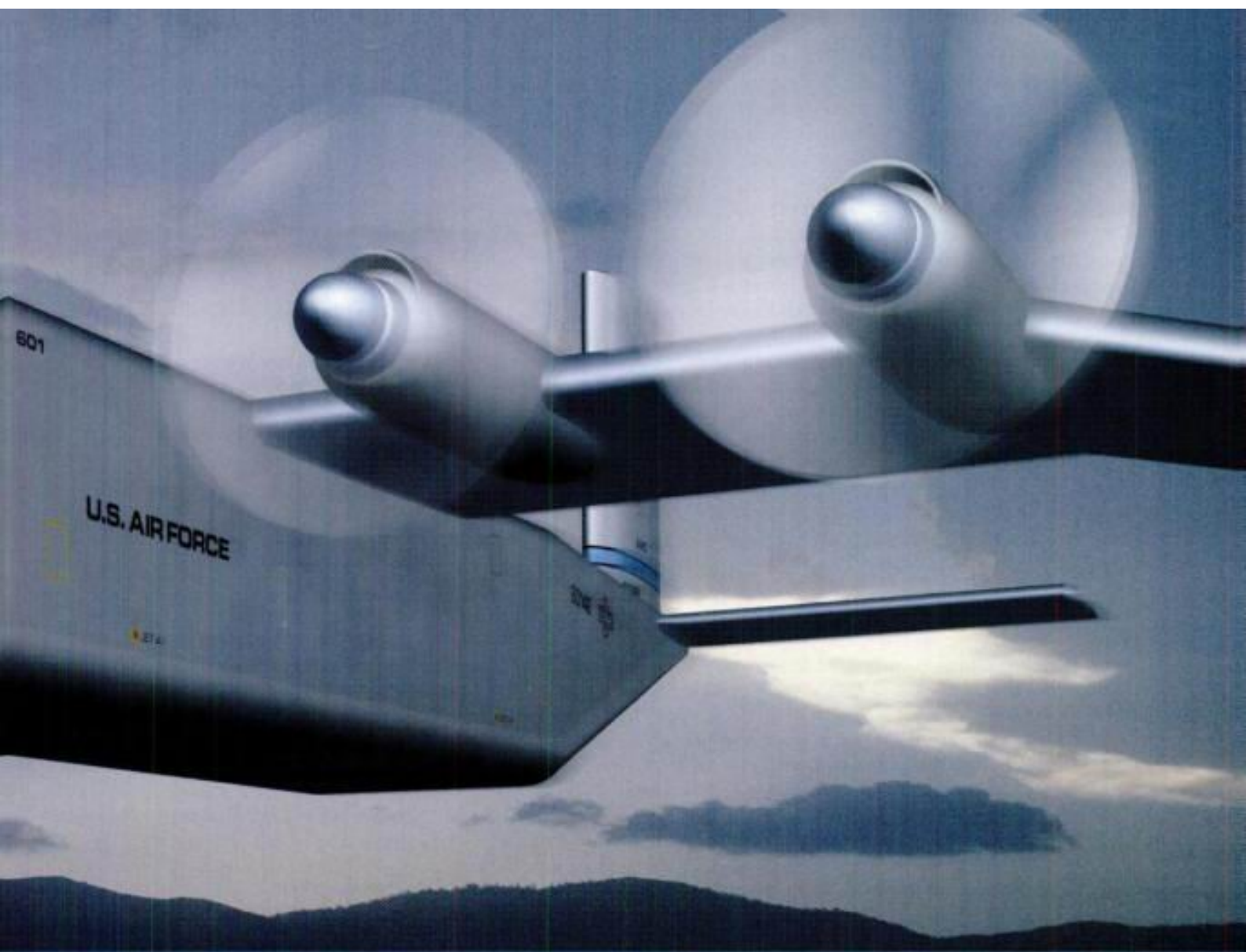


**MAXIMUM
TAKEOFF WEIGHT:**
6 million pounds
**CARGO
COMPARTMENT:**
Holds 2.8 million
pounds (1,400 tons)
SPEED: 300 mph
RANGE: 12,000 miles



LOOK UP, BUT NOT WAY UP: BOEING'S MASSIVE CARGO CARRIER WOULD FLY
MONSTER AT 20





BY BILL SWEETMAN
Illustrations By Mika Grondahl

VERY, VERY LOW INDEED. HERE'S HOW.

FT.

IN THE SUMMER OF 1967, A GROUP OF INTELLIGENCE analysts gathered in the Defense Intelligence Agency's "Green Room," just outside of Washington, D.C., to puzzle over a strange spy satellite image. It showed a gigantic machine, something bigger than any known airplane, with wings that looked too short to fly, sitting in a fenced enclosure at Kaspisk, a small city by the Caspian Sea. "Jeez, that's a monster," said an Army colonel. "Yeah," said another, "the Loch Ness Monster." Someone added: "No, the Caspian. It's the Caspian Monster."

But what was it? How did it work? What did the Russians plan to do with it? The answers came slowly over the next decade: It was an ekranoplan, a new type of aircraft that exploited an aerodynamic phenomenon called ground effect to haul enormous payloads at high speeds over water. It was invented by Rostislav Alexeyev, a friend of Soviet Premier Nikita Krushchev. It was not yet working very well. And if the Amerikanski spies could think of a practical use for it, the Soviet military would have appreciated their advice, because Moscow politicians, keen to find a need for a project that owed its existence as much to connections as to any operational requirement, were hell-bent on ramming it down the armed services' throats.

After the Cold War ended, I asked a Russian aerospace engineer what he thought of the Monster and its descendants, which were being examined intensely by the Pentagon at the time. "A waste of money," he grumbled. "Every time it didn't work, [the designers told Moscow] it would work if it was bigger. And they got the money for it."

But they may have been on the right track. Today, engineers at Boeing are designing a cargo plane that, like the Caspian Monster, is designed to skim just above the water like a large sea bird. It's dubbed the Pelican, because it will use the same "wing-in-ground effect," or WIG, that the awkward bird does to glide almost effortlessly above the water. When applied to man-made flying vehicles, WIG aerodynamics represent a critical exception to a long-held rule of aviation—altitude equals efficiency. The reason most long-range airplanes are high-altitude jets is that flying in thick air at lower altitudes normally takes significantly more fuel. But if you get extremely close to the surface—around 50 feet or below, as a WIG vehicle would—a cushion of air generated by the plane's velocity helps support it in flight, so that the plane cruises even more efficiently than a high-altitude jet. The WIG aircraft Boeing is developing is bigger than the Caspian Monster: Its wingspan is about the width of the front of the Capitol. Boeing engineers are counting on the notion that enormous wings will provide more opportunity for the air below them to gently lift and propel the vehicle, allowing it to skate a mere 20 feet off the water at 300 mph.

The idea of an airplane that weighs as much as seven fully loaded Boeing 747s, and that doubles the distance it can travel by scooting over the ocean surface like a waterbug, may seem far-fetched. But the engineers at Phantom Works, the secretive Boeing think tank, have begun designing this enormous machine because the Pentagon has a major problem that has defeated many less harebrained efforts over the past 40 years. That problem? Mobility. The U.S. Army is a powerful force, but

it is too large and has too much heavy equipment to move at a pace suitable for a fast-expanding conflict. For hauling the Army's equipment, ships are slow and airplanes are small—one division may have more than 300 70-ton Abrams tanks. Even the huge C-5 Galaxy cargo airplane can carry only two Abramses, and the entire Air Force has 126 C-5's.

Defense transformation is eventually supposed to result in a smaller, nimbler Army. But the Pentagon's goal is to move that force faster than it can today, putting a full brigade—3,000 people and 8,000 tons of equipment—on the ground anywhere in the world within 96 hours. John Skorupa, a retired Air Force colonel who now heads the strategic development office of Boeing's Advanced Airlift and Tankers division, dealt with this challenge in his previous job as commander of Air Mobility Command's Battle Lab. "It was clear to us that we never had enough airlift. When we looked at global reach lay-down"—airlifters' jargon for putting forces on the ground—"the airbridge took an enormous number of sorties to move a force of any significance."

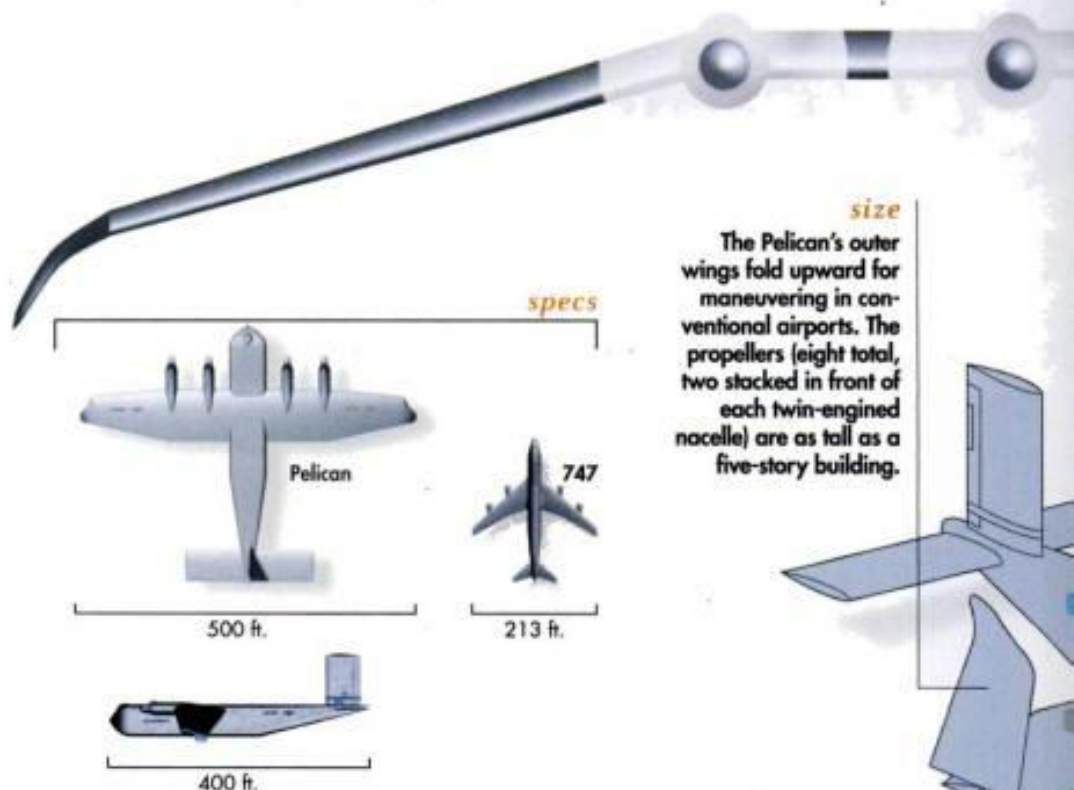
In early 2000, Skorupa, by then at Boeing, took the matter to Blaine Rawdon, a veteran Phantom Works designer who began focusing on the problem with engineer Zachary Hoisington. They knew that the Army was considering airships and airship-airplane hybrids designed to carry multimillion-pound payloads. Rawdon broadened Skorupa's question and looked at a wide range of solutions to the Army's problem, from a new generation of faster small commercial ships to airships to a large, conventional jet airplane, like a quadruple-size C-5. The value of speed always caused airplanes to come out ahead of airships and even the fastest marine vessels, but expanding aircraft to multimillion-pound payloads is not easy and would likely cost more than even the Pentagon can afford.

But ekranoplans, a specific type of WIG with short wings and jet boost for takeoff, seemed to offer some potential—as well as dramatically lower costs, if the concept could be made

WIG idea

PELICAN

IF BUILT, the Pelican will be the largest aircraft ever flown, weighing 3.2 million pounds and able to carry 2.8 million more. The C-5 Galaxy, the largest cargo lifter in the U.S. fleet, weighs at most 769,000 pounds at takeoff. Ten Pelicans could carry the same cargo as a single Navy LMSR (large, medium-speed, roll-on/roll-off) ship, but could cover in one day the distance the ship takes two weeks to travel.



size
The Pelican's outer wings fold upward for maneuvering in conventional airports. The propellers (eight total, two stacked in front of each twin-engined nacelle) are as tall as a five-story building.

feasible. WIG aircraft had attracted an enormous amount of U.S. interest after the breakup of the Soviet Union, and in 1993 the Defense Advanced Research Projects Agency looked into what the Russians had done. Boeing's studies confirmed DARPA's conclusion, as well as that of several Russians, that only a very large ekranoplan made sense, but also that the Soviet vehicle that came close had several inherent problems, mostly relating to its enormous weight. The 500-ton prototype, KM, completed in 1966, had 10 jet engines, two in the tail and eight attached to the forward wing. The 10 engines gulped fuel, and the aircraft had to reach 210 mph before it lifted off the water. The reinforced hull—necessary to withstand the pounding of the waves—significantly increased weight and reduced payload. But despite these weaknesses, the Russian achievements were impressive, according to former DIA analyst Stephan Hooker, who was one of the people in the Green Room on that day in 1967. The plane had less drag than an airplane of the same size, and the Russians had solved many stability and control issues.

But the Soviet Navy's commanders were never enthusiastic about the program. Though the Central Hydrofoil Design Bureau, which constructed the prototype, built two more large ekranoplans—a 140-ton amphibious landing craft and a 400-ton vehicle armed with six anti-ship missiles—the Navy was already building large hovercraft for amphibious assaults and had bombers to strike NATO warships.



hail the ekranoplan

The Soviet Union's 10-engine, 500-ton Caspian Monster prototype was handicapped by the heavy reinforced hull it needed to withstand the pounding waves.

Plus, the ekranoplans lacked the range to be useful as transports. The Navy accepted five out of a planned fleet of 140 and used them for trials, but none ever became operational.

Aware of this long, painful history and the many inherent challenges of WIG aircraft, Boeing engineers have revived the concept, with a key twist. The craft they're designing is a cross between a land-based airplane and a Soviet WIG. It exploits the WIG effect, but it can fly like an airplane over terrain and land at an airport. It doesn't need the ekranoplan's thick, heavy boat hull, or extra power to haul itself out of the water. It has become the Pelican, sharing its broad, drooped wings with the birds that swoop over California's coastline.

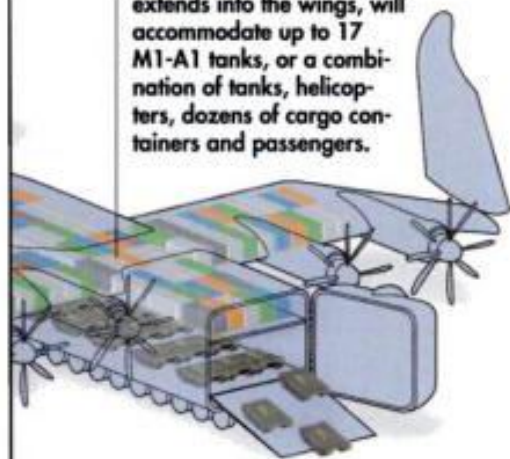
The Pelican, as currently envisioned, will be capable of flying at the same speed and height—300 mph, up to 20,000 feet—as most other airplanes powered by turboprops (jet engines geared to propellers, which, at Pelican's speed, are more efficient than standard jet engines). The difference is that it will cover significantly greater ranges while hugging the water's surface and taking advantage of the ground effect.

There are two elements to the phenomenon. A wing lifts an airplane because the pressure beneath it is higher than the pressure above it—a result of the wing's shape and forward movement. At the lateral tip of the wing, the high-pressure air underneath flows around to the upper surface. This creates a vortex, a rotating airflow that robs the wing of lift. But if the aircraft is flying very close to the surface, there is no room for the vortex to develop properly and it becomes weaker. The sec-



cargo capacity

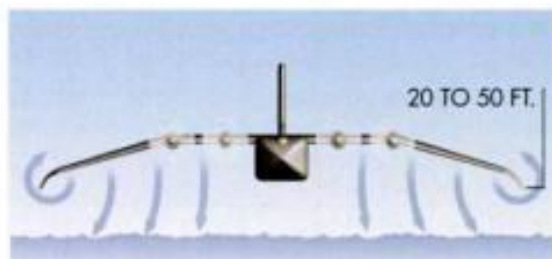
A two-deck, 29,000-sq.-ft. cargo compartment, which extends into the wings, will accommodate up to 17 M1-A1 tanks, or a combination of tanks, helicopters, dozens of cargo containers and passengers.



how it works

The wing-in-ground effect prevents the wing from creating lift-robbing vortices—since at extremely low altitude there's no room for them to form—and generates a cushion of air beneath the aircraft.

The effect is stronger the closer the craft gets to the surface of the water. The Pelican would routinely operate at only 20 to 50 feet, altitudes at which it would burn half as much fuel as an airplane at high altitude.



Craft powered by antimatter, fusion, and solar-driven

Ramjet Fusion Engine

IN ONE interstellar-engine concept, charged particles streaming out at one-third the speed of light would provide thrust for a fusion-powered spacecraft.

Distance to a Star

THE NEAREST STAR is a long way from Earth: Distances are in astronomical units, or AU. One AU is the distance between Earth and the sun, about 93 million miles. The map is not to scale.



sails could take us to interstellar space.

Star Travelers

By Mariette DiChristina

ROBERT FRISBEE IS HUFFING cheerily as he ambles downhill toward a nondescript building on NASA's Jet Propulsion Laboratory campus in Pasadena, California. The San Gabriel mountains form a stunning backdrop, and the sun has warmed the January air to spring-like temperatures, but Frisbee doesn't seem to notice any of it. Indeed, his mind is far away. In interstellar space, to be exact. Frisbee is talking about how we'll someday visit the stars with spacecraft.

If that sounds far out, it is, by nearly every measure you can think of—the tremendous distances between stars, mission trip times measured in decades, and required technological advances so dramatic that even some researchers refer to them as “miracles.” Nevertheless, there's no shortage of well-reasoned ideas about how to conquer the

ILLUSTRATIONS BY BOB SAULS/
JOHN FRASSANITO & ASSOCIATES

Outermost Kuiper
Belt objects

Center of Oort Cloud
of comets

Proxima Centauri

1,000 AU

10,000 AU

100,000 AU

1 million AU

"final frontier." Frisbee and others at NASA centers, universities, research institutions, and companies are laying the groundwork for experiments that will advance the necessary technologies. And while depicting trips to other stars has long been a staple for science fiction writers, today it is the stuff of long-range strategic goals for NASA. The NASA Origins program plans a series of progressively more capable telescopes, culminating in the imaging of Earth-like planets around the nearest 1,000 stars. Building on that, NASA Administrator Dan Goldin has said he wants the agency to launch interstellar missions in the next 25 years. To drive the necessary advances, "We have to set goals as tough as they hurt," Goldin has said.

Even at this embryonic stage, it's already more than apparent that the task is as difficult as it could possibly be and still remain possible—scientists *think*. Start with the vast scale of the cosmos. Voyager I, launched September 5, 1977, illustrates the scope of the problem. After speeding along for more than 20 years, it is now 6.8

billion miles away from Earth traveling at nearly 51,000 mph. That's about 10 light-hours away. (A light-hour is the distance light travels in one hour at 186,000 miles per second.) But the closest star to Earth is Proxima Centauri, which is 4.3 light-years, or 25 trillion miles, away. If Voyager were pointed in the right direction, Frisbee and JPL colleague Stephanie Leifer calculate that it would take some 74,000 years to make the trip. But interstellar missions must occur on a human time scale—preferably within an individual's lifetime. That means a maximum of 40 years for a "slow" mission, and a far more desirable 10 years for a fast one.

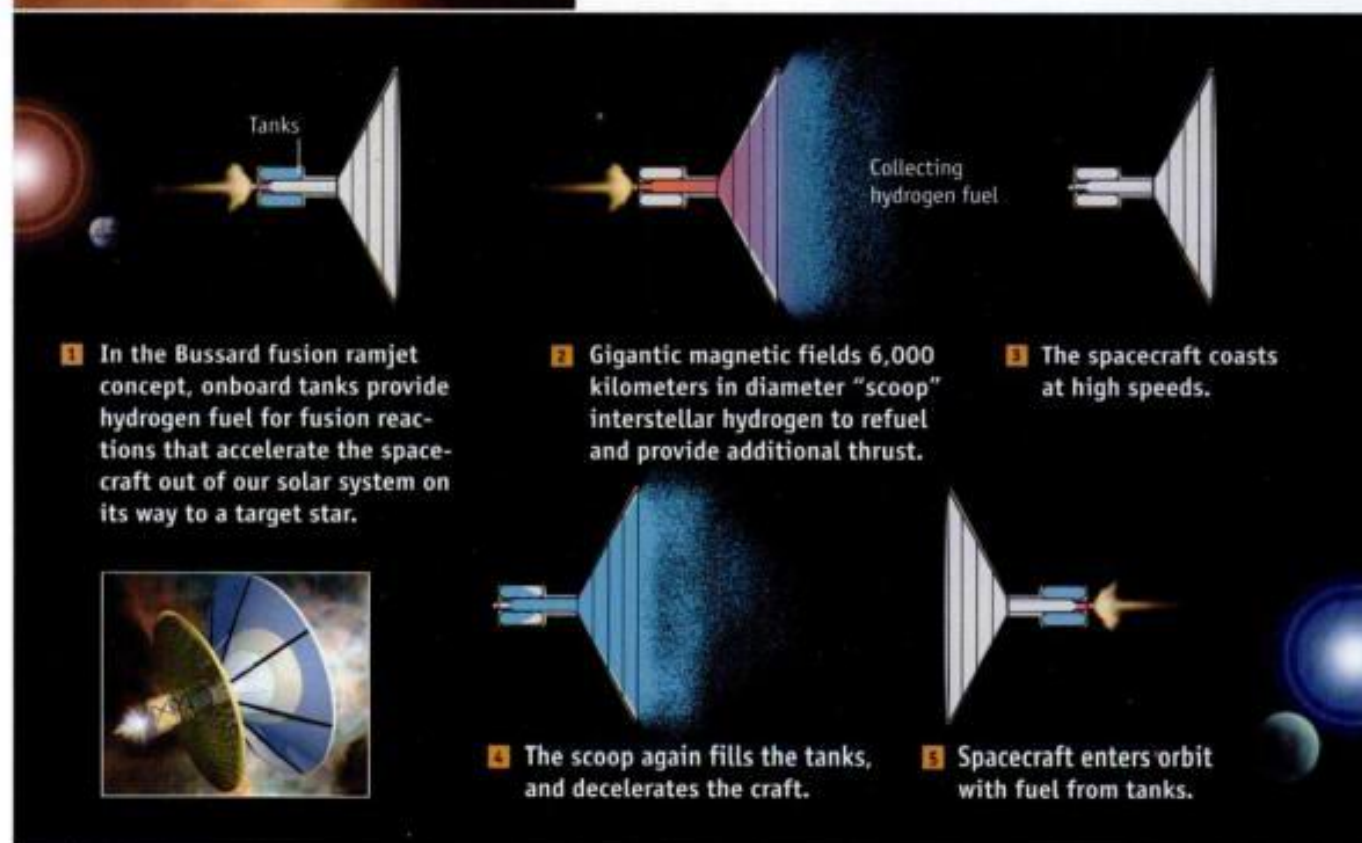
And then there's Einstein. A spacecraft that aims to cross vast distances at high speeds also must contend with the theory of special relativity. The theory mandates that as an object approaches the speed of light, its mass increases. To get to Proxima Centauri in, say 10 years, the craft would have to whiz along at nearly half light speed. At that velocity, it would become 1½ times more massive than it was originally. Frisbee, a chemist

whose job it is to analyze such missions, puts it another way: "If you take a 1-ton spacecraft, such as Voyager, and bring it up to one-half the speed of light, it'll require one month's worth of all the energy produced today by humans." Even if it were possible to build a big enough fuel tank, conventional chemical rockets don't have the power, or energy density, to do the job.

One last thing: It's one kind of propulsion requirement to get up to speed and coast for a fly-by mission, as Voyager did to the outer planets in our solar system. But to stop to orbit or land at an interstellar target, the spacecraft has to expend energy to slow down. "From a propulsion point of view," says Frisbee, "we've immediately doubled the requirements."

So what's an interstellar mission planner to do? "When all is said and done, you're kind of stuck with fusion or antimatter [for an onboard engine]," says Frisbee. "Even fission doesn't have enough energy." The other chief option, he says, is to leave the engine at home. Solar-powered lasers parked in orbit around our sun, for instance, could push craft with

FUSION RAMJET



thin sails across space. "Right now, based on our current level of ignorance, they're all equally impossible . . . or possible," says Frisbee.

Take antimatter, for instance. If antimatter comes in contact with regular matter, they annihilate; the mass of both is turned into energy. "The antimatter-matter reaction has the highest energy density we know of," says Stephanie Leifer of JPL. The reaction releases charged particles, which could be directed out the back of a spacecraft for thrust using magnetic "nozzles." The charged particles move very fast, approximately one-third the speed of light. However, says Leifer, "We don't know how to make nozzles big enough [for an antimatter engine]. It's not totally infeasible, but it's very tough."

Add to that another big problem. A pure antimatter engine would need thousands of tons of antimatter, plus matter, on the order of the size of the Washington Monument. But today, mere nanograms of antimatter are made at special laboratories like Fermilab and CERN. "We'd probably have to have an infrastructure in space, to harvest the antimatter," speculates Leifer.

The effort might be defensible, since antimatter could be used for medical applications like imaging and destroying certain cancer tumors. But then there's another issue. Antimatter also can't contact matter, so it's been difficult to store more than a tiny amount in magnetic traps, which keep charged particles from hitting the matter containment walls and annihilating.

Enter physicist Gerald Smith and his team at Penn State. Smith suggests a way to vastly reduce the antimatter requirements.

"We'll never have even a ton of antimatter, in my view," he says. "We think we can ignite with a microgram of antimatter, which we can foresee doing with the current technology." Ignite what? A fusion reaction.

His team is attacking the problem

on several fronts. First, successful tests with a shoebox-size antimatter trap built at Penn State that could theoretically hold 100 million antiprotons, or positively charged particles of antimatter, have inspired researchers to build a larger one with the Marshall



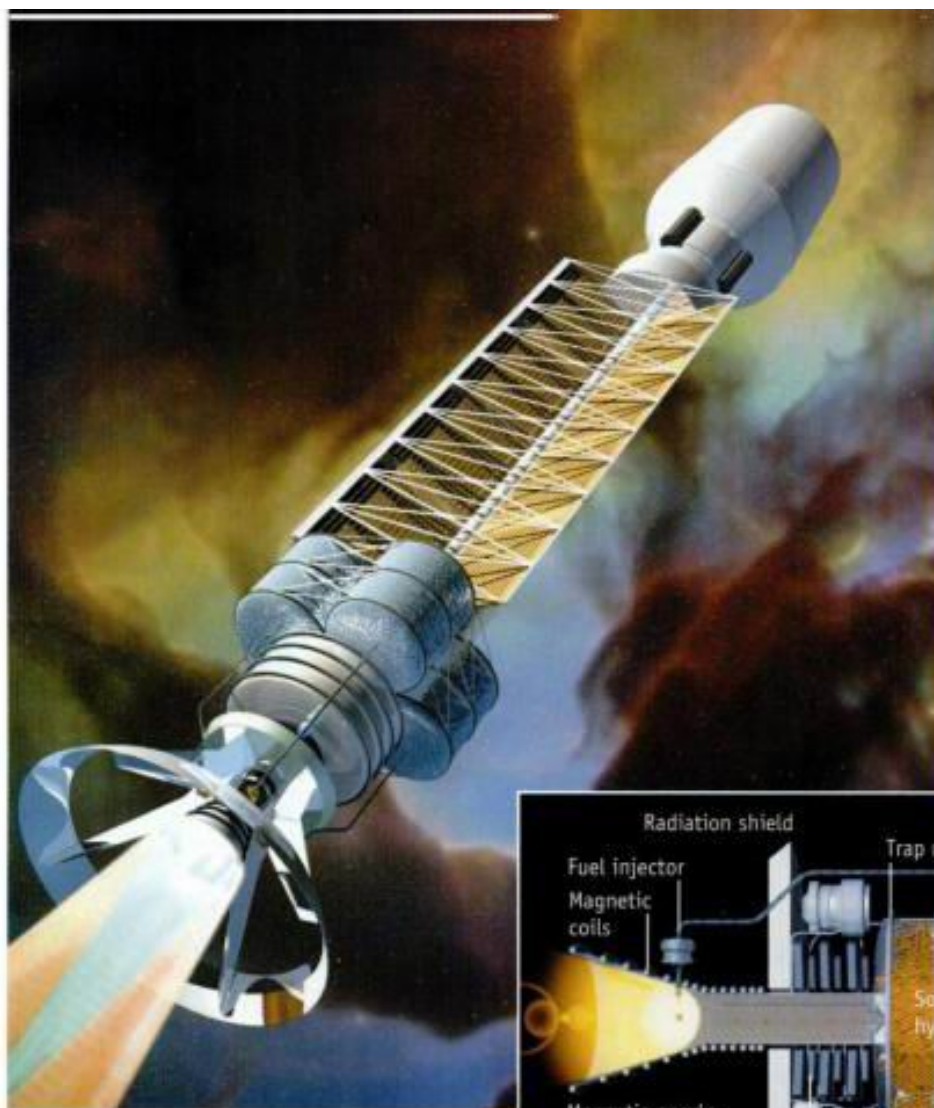
SOME TENS OF KILOMETERS in diameter and just a few atoms thick, lightweight lightsails, **1.**, would be pushed by an orbiting laser beam powered by the sun for a 4.5 light-year trip to another star in 20 years.

2. After being pushed for months or years, the sail spacecraft would coast to the target star system.

3. A second-stage sail would be used to decelerate; **4.** then the lightsail goes into orbit around a selected planet.

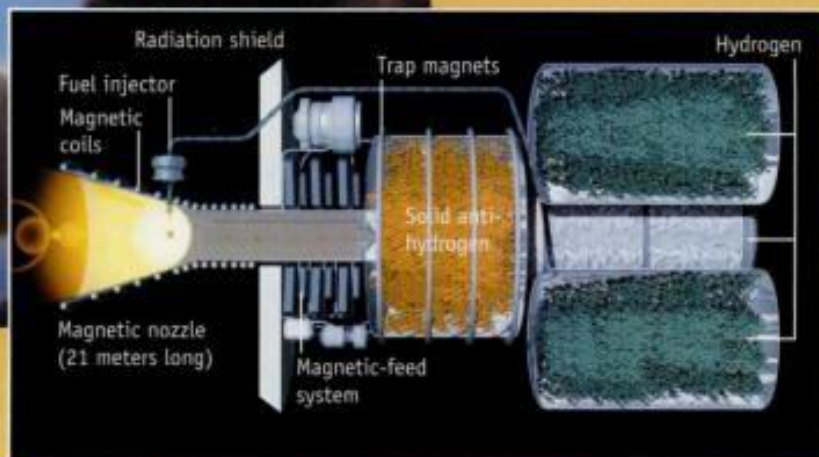
Space Flight Center in Huntsville, Alabama, to be finished this summer. Smith estimates it could hold 10,000 times as many antiprotons as the smaller trap. The trap will enable eventual tests with a planned antimatter plasma gun, which will be used to ignite the fusion reaction.

Nuclear fusion, which happens in



MATTER-ANTIMATTER

WHEN MATTER CONTACTS antimatter, they annihilate each other, releasing energy in greater densities than any other reaction known. In a beam-core engine system concept, hydrogen and anti-hydrogen are fed from a spacecraft's onboard storage tanks. They contact in a chamber and the resulting products are directed out the back of the spacecraft by magnetic "nozzles" for thrust.



the hearts of stars like our sun, requires tremendous pressures and temperatures. "Low" temperature fusion starts at 1.5 million degrees Celsius. The antimatter plasma gun is intended to create temperatures hot enough to trigger fusion. To date, experiments with fusion have managed to maintain the reaction for only a few seconds before it burns out.

That's where the third part of Penn State's efforts, developing engine concepts, comes in. Smith's Aimstar engine concept offers a way to maintain the fusion reaction. It starts with a small amount of antimatter,

which comes into contact with lead or uranium, causing it to fission. The energies released by the fission help drive the fusion reaction of deuterium, or "heavy" hydrogen, and a form of helium. The high temperatures create a plasma of negatively charged electrons and the positive nu-

clei of atoms. Magnetic nozzles direct the charged particles for propulsion.

But with such hot temperatures, wouldn't the nozzles be destroyed? "I'm working on that," promises Smith.

Another Smith concept gets around the problem of melting by, in effect, melting away only a little at a time. "We're working our heads off to move forward as fast as we can," he says. "Because if there's a technology that's capable of going to the stars, it's antimatter."

Another fusion approach, called the Bussard Ramjet, attempts to solve the weight problem by not taking much fuel at all. Instead, the concept calls for a gigantic magnetic field "scoop" that would harvest what it needs from interstellar space. The scoop is, of course, far bigger than

any that has ever been generated on Earth—about the distance from Earth one-third the way to the moon, at a strength hundreds of times what is possible in labs today. Leifer of JPL describes the system: "You need to pick up your fuel, compress it and heat it, and expel it out the back without slowing down the spacecraft," she says, "and we don't know how to do that either."

Solar sails may be initially more promising than antimatter or fusion, says Frisbee. "In terms of a closest and cleanest development program, solar sails may be the first step." The idea was first conceived decades ago by Robert Forward, a retired Hughes physicist who now consults for NASA; heads Forward Unlimited, a Clinton, Washington, company that

Missions in search
of other planets

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EDITED BY DAWN STOVER

BALLOONS

Floating to Victory

RIVAL BALLOONISTS had their hopes partially deflated this spring when Swiss psychiatrist Bertrand Piccard and British balloon instructor Brian Jones took their place in history as the first men to circle the globe in a balloon.

Launched from Château d'Oex in the Swiss Alps on March 1, the *Breitling Orbiter 3* balloon effortlessly headed toward Morocco over Mauritania, and then turned northeast to catch a jet stream—high-altitude winds that usually flow from west to east. Balloon pilots generally “steer” their balloons by rising or dropping to catch different jet streams. *Orbiter 3* got lucky; the balloon sped toward India at 60 mph, and in the home stretch caught a 100-mph jet stream over the Atlantic to float to victory in Southeast Egypt. The feat took 20 days.

The trip was not without a few glitches. *Orbiter 3* lost contact with mission control for four days while over the Pacific Ocean, and a broken heater dropped the cabin temperature to a chilly 46°F. And as the balloon crossed the Atlantic, its fuel levels dropped dangerously low. But the problems were relatively minor considering that just a week earlier competitors Andy Elson and Colin Prescott plunged into the Pacific after their balloon *Cable & Wireless* was ripped apart by a thunderstorm.

Since 1981, there have been more than 20 attempts to circle the globe in a balloon, and *Orbiter 3*'s triumph isn't likely to stem the tide. There are still records to be broken. “The altitude record for a manned balloon is 113,000 feet,” says Dave Liniger of Team Re/Max, a group planning to launch with two pilots later this year [“3 Men, a Balloon, and Their Quest for a Place in History,” Jan.]. “We will break this record on the first day by climbing to 130,000 feet.” *Orbiter 3*, by contrast, reached only 39,000 feet, but it did set distance and duration records. Liniger thinks that future balloonists might attempt to traverse even greater distances with higher-tech equipment and attempt to stay aloft even longer.

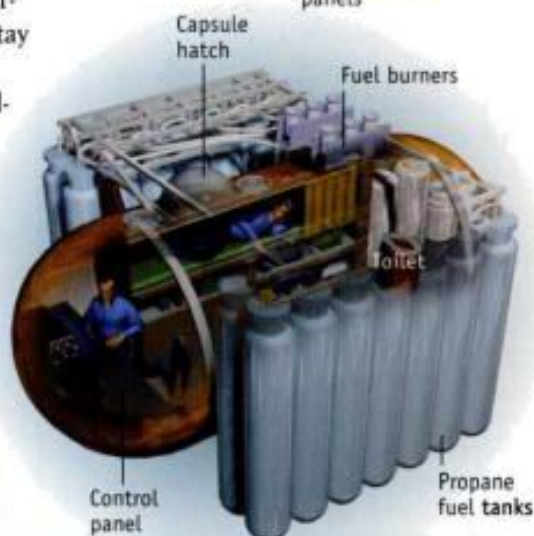
“We want to prove the technology of stratospheric ballooning even if we don't break any records,” Liniger adds. “We will be conducting a civilian adventure into near space with several valuable scientific experiments, including reporting live to millions of people.”

Meanwhile, rival balloonist and British recording-industry tycoon Richard Branson has said his new ambition is to sponsor an around-the-world balloon race, with his company, Virgin Group, footing the bill.—Gunjan Sinha



Orbiter 3

THE HUGE craft is really three balloons in one. Hot air keeps a shrinking helium cell aloft at night. A smaller helium cell holds up a tent that helps conserve heat.



During their 20-day voyage, the two pilots took turns sleeping in the single bunk of the pressurized capsule.

IN HIS OFFICE at the Jet Propulsion Laboratory in Pasadena, California, physicist Mark Adler holds a transparency up to the light. He points to a timeline laying out NASA's ambitious program for the exploration of Mars. The timeline shows missions that will be sent to study the martian soil and atmosphere, to analyze rock samples, and even to bring rocks back to Earth. Then Adler points to the year 2014. There the timeline ends with a stunning climax: a human mission to Mars.

Nearly three decades after landing on the moon, NASA is once again devoting serious study to human spaceflight beyond Earth's orbit. This time, the most likely target is Mars. The costs of a two-and-a-half-year human mission to Mars, once estimated to be in the hundreds of billions of dollars, have now fallen to as low as \$20 billion, or about \$2 billion per year for 10 years. That fits well within NASA's budget constraints; the agency now spends that much on the International Space Station. And the most recent feasibility studies from NASA's Johnson Space Center in Houston suggest that Adler's timeline may be too pessimistic. JSC engineers are now saying they can deliver astronauts to Mars in less than a decade.

"We're laying the groundwork," says Adler, the architect of JPL's program to explore Mars with robots in advance of human exploration. NASA, which waited 21 years after the 1976 Viking mission to go back to the surface of Mars with Pathfinder, has now set up a Mars assembly line. While Pathfinder's rover was scurrying over the martian surface, engineers were already planning the Mars 98 mission. Missions are also planned for the next launch opportunities in 2001 and 2003. (Fuel requirements are lowest if spacecraft are launched when Earth and Mars are nearest each other; such "opposi-

Prodded by a visionary outsider,

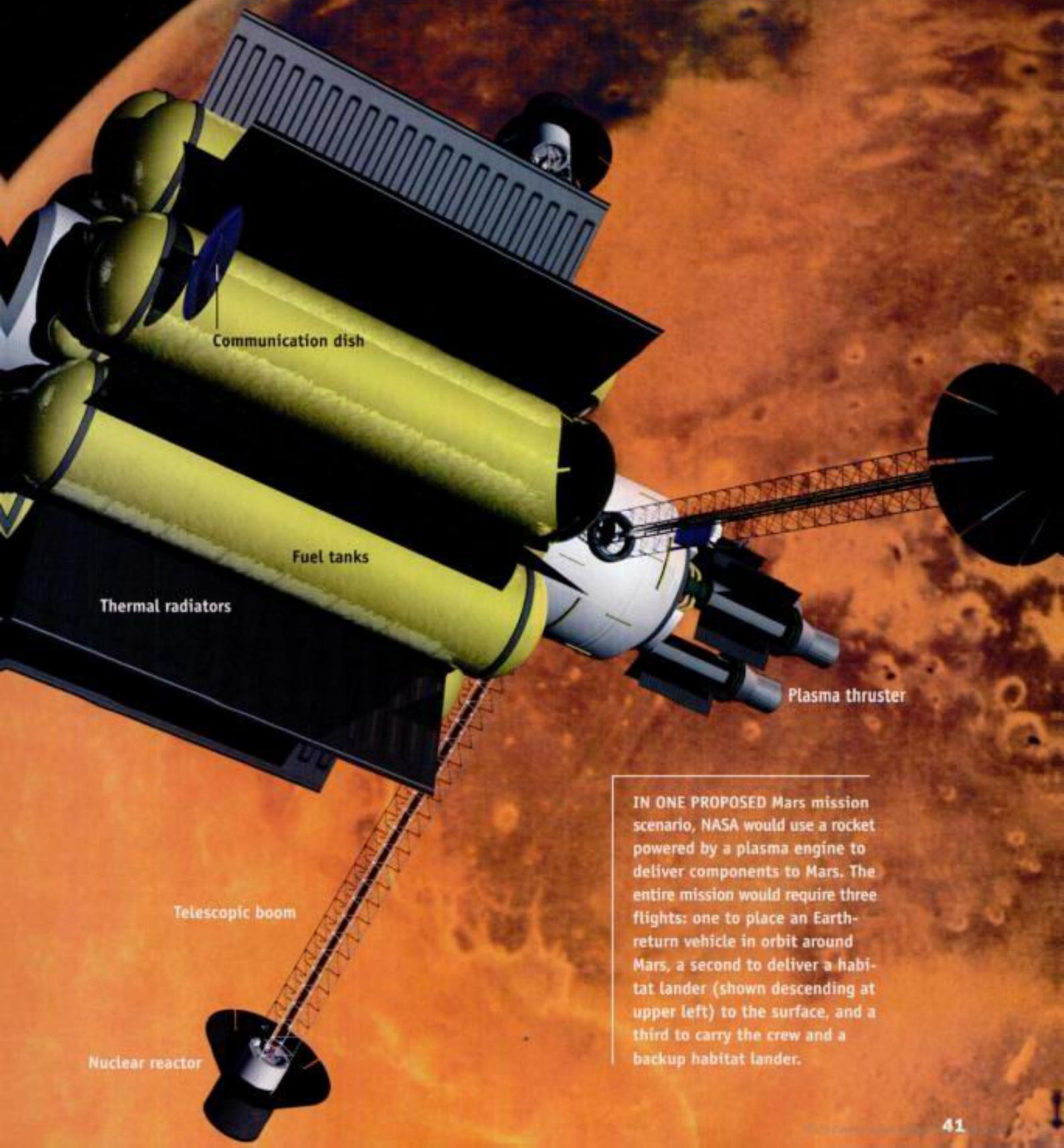
Manned Mission to Mars

An illustration of a white manned Mars mission spacecraft in orbit above the planet Mars. The spacecraft is cylindrical with a conical nose cone and has several windows and antennas visible. It is shown from a three-quarter perspective, appearing to be in a circular orbit. The planet Mars, with its characteristic orange and red hues and darker surface features, occupies the lower right portion of the frame. The background is a deep black space.

By Paul Raeburn

ILLUSTRATIONS BY BOB SAULS/JOHN FRASSANITO & ASSOCIATES

NASA has devised a new plan for sending astronauts to Mars.



IN ONE PROPOSED Mars mission scenario, NASA would use a rocket powered by a plasma engine to deliver components to Mars. The entire mission would require three flights: one to place an Earth-return vehicle in orbit around Mars, a second to deliver a habitat lander (shown descending at upper left) to the surface, and a third to carry the crew and a backup habitat lander.

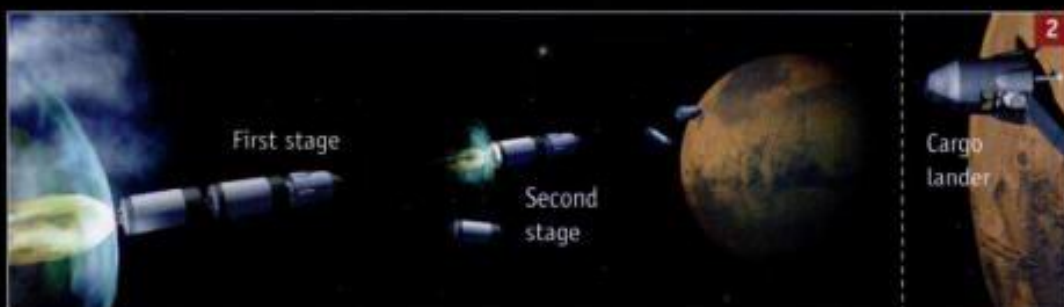
NASA REFERENCE MISSION

THE STANDARD AGAINST which future proposals for Mars exploration will be measured, NASA's Reference Mission calls for three flights that would deliver a crew of six astronauts to the surface of Mars for a 500-day stay. NASA engineers currently estimate the cost of the mission could be as low as \$20 billion.

For each flight, three stages are launched separately into low Earth orbit and assembled there. The crew arrives in a shuttle before the final flight departs.



On the first flight, an Earth-return vehicle (ERV) is placed in orbit around Mars. It is delivered fully fueled, and remains in orbit for nearly four years, until the first crew is ready to come back to Earth.



Shortly after the ERV is launched, a cargo lander is sent to the surface of Mars. It contains an unfueled ascent vehicle, a propellant production plant, liquid hydrogen, a nuclear power plant, and an inflatable habitat.



Once the ERV and cargo lander have arrived and been tested, and the lander has produced sufficient fuel for the ascent vehicle, the crew arrives in a second lander and installs the inflatable habitat.



After spending about 500 days exploring Mars, the crew uses the ascent vehicle to rendezvous with the ERV in Mars orbit. The return trip ends with a direct entry; the crew lands in a capture vehicle using a steerable parafoil.

MARS DIRECT

TO SAVE TIME AND MONEY, the Mars Direct plan would send components straight to the surface of Mars, without stopping to orbit Earth or Mars. This approach requires a much smaller crew capsule, and a crew of four astronauts rather than six.



The first flight sends an unmanned Earth-return vehicle to the surface of Mars aboard Ares, a launch vehicle derived from the space shuttle. The ERV begins making fuel for the trip home.



While traveling to Mars, the lander is joined to the spent Ares upper stage by a 1,500-meter-long tether. They spin at one rpm to create an artificial gravity equivalent to that of Mars.



A second ERV lands automatically, providing a backup vehicle in case the first one malfunctions. The ERV carries a nuclear reactor that supplies power for making fuel, water, and oxygen.



The first crew departs in the original ERV, and a second crew arrives in a new lander. The tether and spent upper stage are released before the lander touches down on the surface of Mars.



A third ERV is sent to the surface as a backup. If the second ERV is functioning properly, the second crew uses it to return home, leaving behind both crew landers for future visitors.

Cutting Edge Engines

NASA IS DEVELOPING a variety of advanced rocket-propulsion systems, some of which might be used in human Mars missions. Here are the most promising alternatives to conventional chemical rockets:

SOLAR-ELECTRIC PROPULSION Electricity generated by solar cells is used to ionize atoms of xenon or krypton. The

electrically charged ions are accelerated through an electromagnetic field and expelled, generating thrust in the opposite direction. Ion propulsion has already been used to keep an Earth-orbiting satellite in position, and to power the Deep Space 1 probe launched a few months ago.

NUCLEAR ELECTRIC Similar to solar-electric propulsion, but electricity is generated by a nuclear reactor.

PLASMA An ion engine with an afterburner, in which radio waves or other means are used to add energy to the ions. They are then compressed to form a plasma before being expelled. Plasma engines produce higher thrusts but consume more power.

NUCLEAR THERMAL Hydrogen is heated by a nuclear power source to nearly 5,000°F and expelled at supersonic speeds from a nozzle.—P.R.

payload is only about 20 metric tons, but when it's loaded, the weight of the orbiter is about 80 metric tons. "You can think about replacing the orbiter with payload, and you essentially have a system in place that can almost do what we want to do."

This new launch vehicle is referred to as the Magnum. Like the space shuttle, the Magnum would have a large fuel tank with two attached booster rockets. But in place of the shuttle orbiter would be a long cylinder mounted atop the fuel tank. That cylinder would house the elements of the Mars mission.

The Magnum would put the components of the Mars mission into low Earth orbit, comparable to the orbits the shuttle flies. There they would be assembled in preparation for the trip

to Mars. In one scenario, the finished package would not go straight to Mars. Instead, NASA would use a space "tug" to slowly haul each Mars payload into a much higher Earth orbit. From there, it takes only a small additional kick to get the payloads on their way to Mars.

The details of the space tug design are constantly being updated. **The latest plan envisions a spacecraft with a solar-electric ion engine,** but NASA is also considering chemical, nuclear electric, nuclear thermal, and plasma propulsion systems.

Once the space tug takes the payloads into high Earth orbit, it will disconnect and lower itself back to pick up another payload. The payloads in high Earth orbit will be sent on their way to Mars with a short burst from a conventional chemical rocket.

The principal advantage of ion en-

gines is that they're very efficient, but they don't provide a lot of thrust. The trip from low to high Earth orbit takes about six months. That's fine for the unmanned payloads, but what about the astronauts? Once the payload with their second habitat has reached high orbit, "You shoot the crew up there quickly in a smaller system," says Joosten. "It's sort of like the dinghy that goes back and forth to the big ship moored offshore."

Zubrin is not in favor of using advanced propulsion systems such as solar-ion engines for the early Mars missions, because he is afraid that the development of such systems could delay the overall mission. Columbus, Zubrin notes, did not wait to develop trans-Atlantic sailing vessels before wandering off in search of a new world. "Once he did that—once people knew there was some place to go—then you

NASA REFERENCE MISSION

AT THE END of their stay on Mars, the astronauts will leave behind a cargo lander (minus its ascent vehicle) and a crew lander with attached habitat. These could be used by future crews.

The crew lander can be moved a short distance on wheels when its landing legs are retracted, making it possible to connect two modules.

Wearing pressurized suits, the astronauts will use a rover to venture as far as 10 kilometers from their habitat.

Crew
lander

Cargo
lander

Inflatable
habitat

Thermal
radiator

Unpressurized rover



had the development of three-masted frigates and steamships and ocean liners and Boeing 747s. Destinations drive transportation."

Zubrin's Mars Direct mission is smaller and lighter than NASA's. He has in mind a crew of four, not six. He would begin in 2005 with the launch of a vehicle similar to the *Magnum*. It would carry an Earth-return vehicle directly to the surface of Mars, without stopping to orbit Earth. A direct flight, Zubrin says, would eliminate the need for a space tug or any other additional hardware in orbit.

Zubrin's mission saves weight by using a smaller habitat, one that NASA believes is too small. "You can't put them in an Apollo-size capsule for six months," says Joosten. NASA's mission calls for a larger capsule, one that is too heavy for a direct mission.

In Zubrin's plan, a second Earth-return vehicle would be sent to Mars two years after the first one. As with NASA's mission, this would serve as a backup, or it could be used by the second crew sent to Mars. A few weeks after the second Earth-return vehicle is launched, a crew of four would be sent to Mars, again by a direct flight from Earth to the surface of Mars. After 500 days or so on the surface, the crew, using propellant produced on Mars, would fly directly back to Earth,

without stopping to orbit Mars.

Zubrin's mission requires only two launches, while NASA's requires three. That makes NASA's inherently more expensive. And, as Zubrin points out, NASA's plan depends upon a "mission-critical" rendezvous in Mars orbit. On the other hand, Zubrin's mission requires that far more fuel be made on the surface—enough to get the astronauts home, not just into Mars orbit.

While most of the technology to get to Mars is in hand, some important challenges remain. "We really want to get a lot of information back from the space station," says Bret Drake, who leads the human mission study at JSC's Exploration Office. "How the body adapts to zero gravity is one of the main things." Life-support systems and other technology can also be tested aboard the space station.

NASA isn't waiting for the completion of the station to begin its studies, however. The plans for a human Mars mission will advance beyond the design stage in only two years, with the launch of the Mars 2001 mission. The unmanned spacecraft will carry a small-scale version of the propellant-production system.

On the unmanned mission that is planned for 2003, NASA is considering studies that will explore the possibility of "air capture." NASA wants to find out if it can put a spacecraft into orbit around Mars by using the fric-

tion of the atmosphere to slow it down, rather than a rocket burst. Air capture would reduce the amount of fuel needed for a martian mission.

NASA might also use the 2003 mission to produce methane on the surface and to test schemes for more precise landings. *Pathfinder* was designed to land somewhere within a 300-kilometer "error ellipse." With a human mission, the error ellipse will need to be no longer than about 3 kilometers, Drake says.

Zubrin will also be busy preparing for the future. Working with the newly formed Mars Society, he hopes to raise \$1 million for the construction of a Mars habitat module in the Canadian Arctic. "We want to have that up and running by 2000. If we can do that, we can raise perhaps \$5 million to \$10 million to fly a hitchhiker payload to Mars by 2003," he says, perhaps on a planned European Mars probe. One idea for the payload is a balloon-mounted camera that would drift through the martian atmosphere and send back a bird's-eye view of the planet. Zubrin's group eventually hopes to raise enough money to fly a robotic mission of its own to Mars.

Nearly 30 years after the first moon landing, it now seems that interplanetary exploration has once again become a real possibility. "It's definitely going to happen," says Drake. "It's just a matter of time." ♦

MARS DIRECT

AFTER TWO SETS of astronauts have come and gone, a pair of crew landers and an Earth return vehicle will remain on the surface of Mars. As with the NASA plan, components left behind become spares for future crews.

Fuel tanks

The landers contain compartments for sleeping, eating and lounging, exercising, and doing science experiments.

This vehicle manufactures fuel for the return trip to Earth by extracting ingredients from the martian atmosphere.

Crew lander

Crew lander

Earth-return vehicle

Deployable heat shields



Space Shuttle Orbiter

—ready for test flight



Riding piggyback on modified 747, Orbiter 101 will be carried aloft for its first test flights. Special tail cone will cover three rocket engines on some tests to reduce aerodynamic drag.

By JIM SCHEFTER

Struggling for altitude in the hot, thin desert air, its massive payload pressing down on its back, the modified Boeing 747 mother ship staggers to 24,000 feet. Explosive bolts blow with audible pops. The 747 lurches forward and down. Like a baby whale cast loose, Space Shuttle Or-

biter 101 lifts away and is flying.

But "flying" may be too generous a term for what happens next. The pilots of the Orbiter, sinking at more than 10 feet per second, pull up the nose of their unpowered craft for a practice flare and "landing" at altitude. At 18,000 feet, less than a minute since free flight began, the maneuver ends. It's the



Launched from the 747 at 28,000 feet, the Orbiter will glide to an unpowered landing three to four minutes later—or less with tail cone off, as at top left. Middle left: Huge craft will be delivered by truck over back roads in the Mojave Desert from Palmdale, Calif., where it's being built, to Edwards Air Force Base, where tests will be done. Bottom left: Rear view of Orbiter shows rocket engines that will assist Orbiter's launch into space—around 1980. Below: Model of rear half of solid rocket booster is tested to see how hot it might become during its tumbling re-entry into the earth's atmosphere after the Orbiter is lifted into space. Differences in temperature—ranging from red hot to cool—are made visible by using materials whose ultraviolet radiation varies with temperature.



last chance the pilots have to feel out their machine before landing.

Banking left through a 180-degree turn, now plummeting at nearly 200 feet per second, the pilots lock on to the special microwave landing system installed on the 15,000-foot Mojave Desert runway. Onboard computers monitor every inch of the descent; a "fly-by-wire"

avionics package that may be the most advanced in the world gives the pilots precision control down the glide path.

At 24 degrees, this glide path is eight times steeper than the slope used by commercial airliners. Screaming downhill toward the runway at 300 knots, the Orbiter is pulled into the final flare a mile out

and 1900 feet up. At 500 feet the pilots drop the gear and pick up a normal three-degree glide path.

Seven seconds later, the Orbiter touches down at 175 knots. The pilots tap the toe brakes gently to affirm human command.

That flight profile, with variations from flight to flight, will be

Continued

Around-the-World Balloons

WITH FOUR RIVAL TEAMS planning to launch globe-circling balloon voyages near the end of the year, a race of sorts is underway. Each team is using a different strategy in its quest for the record. Some balloons are larger than others. Some fly higher than others. And some cost more: Expenses are estimated at \$360,000 for *Solo Challenger*, \$1.3 million for *Odyssey*, \$3.5 million for *Unicef Flyer*, and \$10 million for *Virgin Challenger*.

Unicef Flyer

Flown by a two- or three-man Dutch team, it will hitch a ride in the jet stream, about seven miles up, zip-ping around the world at speeds between 100 and 250 mph. The crew plans to launch from the Netherlands sometime this winter.

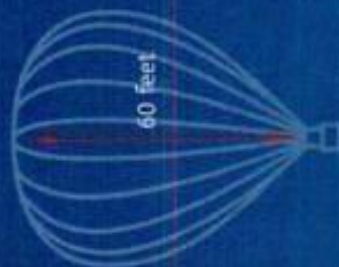
Virgin Challenger

A British crew of three will also fly in the jet stream. They could experience dramatic G-forces when their balloon first hits the fast-moving air. Sponsors planned a February launch in Morocco, but the jet stream didn't cooperate. They'll try again between

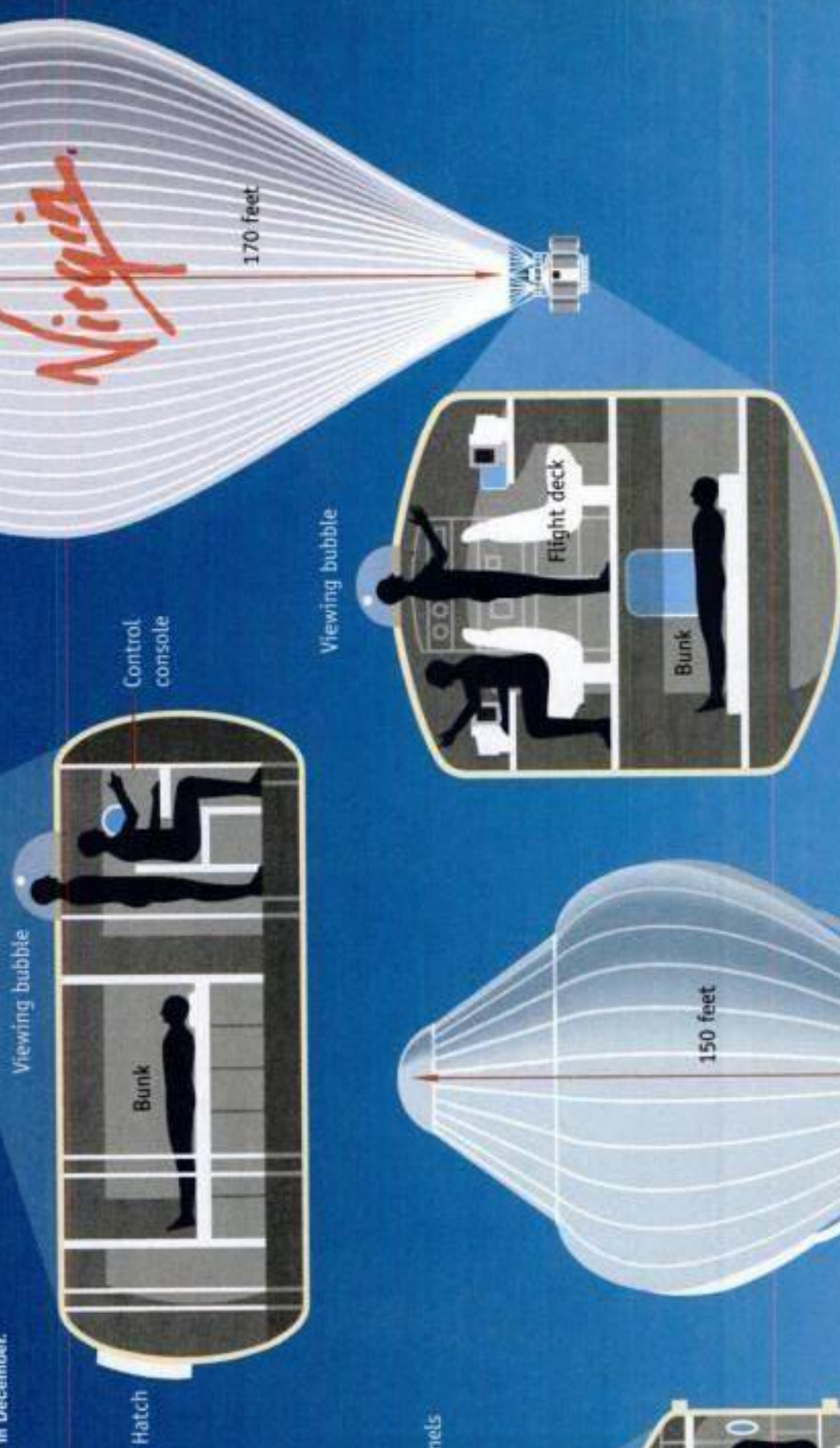


Parachute

The largest of the four balloons when fully inflated, it will fly about 24 miles above Earth in the stratosphere, drifting along at 50 to 60 mph. In an emergency, a parachute could lower the three-man American crew to safety. They plan to launch from Australia in December.

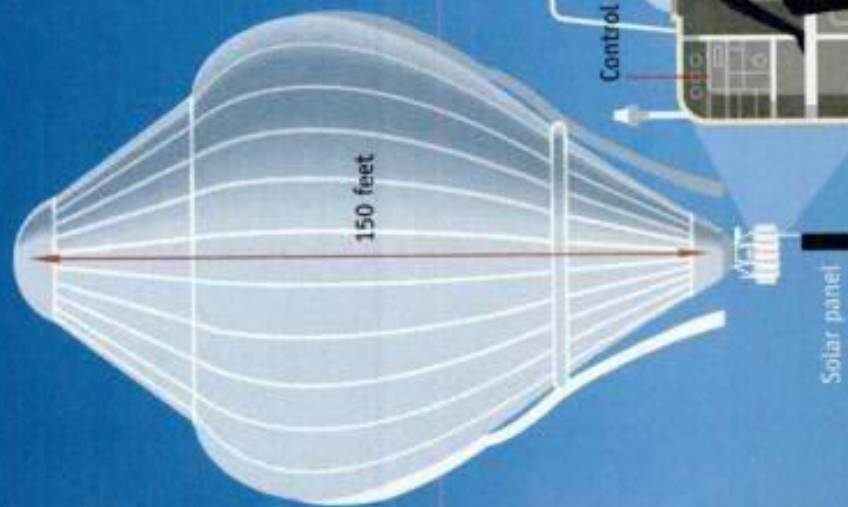


Conventional hot-air balloon to same scale as balloon drawings.



Solo Challenger

Flying alone, Steve Fossett cruises 4 1/2 miles above the ground at a leisurely pace of about 50 mph. He flies high enough to require oxygen for breathing in his unpressurized gondola—the only one with a viewing bubble that can be opened. But he flies low enough to worry about storms and heat-seeking missiles. Fossett made his first attempt in January; he plans to be ready again by this November.



All capsules are shown at the same scale.





Gannet

The oceans harbor at least as great a variety of life as do the lands. An estimated five million species, most of which have not yet been classified, reside beneath the waves. The web of marine life starts with the tiny phyto-

plankton, young shrimp, and other small animals. Moving up the food chain we find sponges, corals, mollusks, and other sedentary animals; then mobile creatures, including hard-shelled crustaceans; soft-bodied squids and jellyfish; eels and snakes; and small fish. At the top, of course, lurk large predators like killer whales, swordfish, and sharks.

The densest life exists in the first 200 meters of water. Below this, little light penetrates and the population density declines sharply. However, the *diversity* of life remains great even on the ocean floor, where explorers have discovered everything from giant clams to hose-like red tube worms.

Here's a sampling of ocean life—from small to large, and from common to exotic.



Phytoplankton



Zooplankton



Herring



Anchovy



Shallow-water Squid



Bonito



Mackerel



Roosterfish



Snapper



Albacore



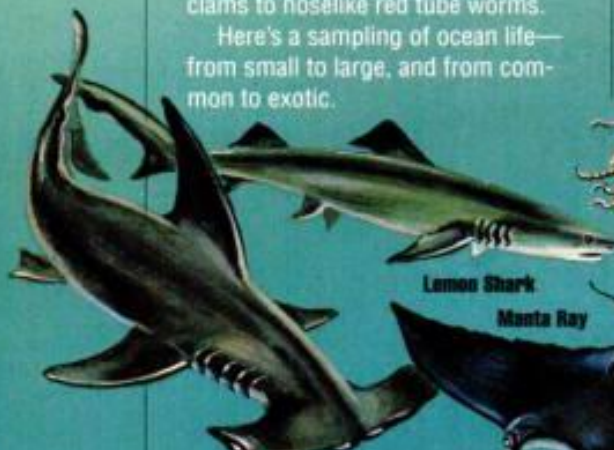
Salmon



Barracuda



Octopus



Hammerhead Shark



Manta Ray



Skate



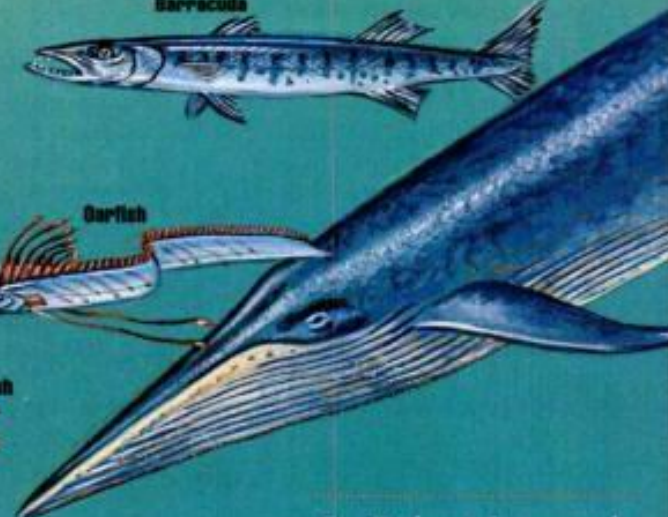
Garfish



Deep-sea Squid



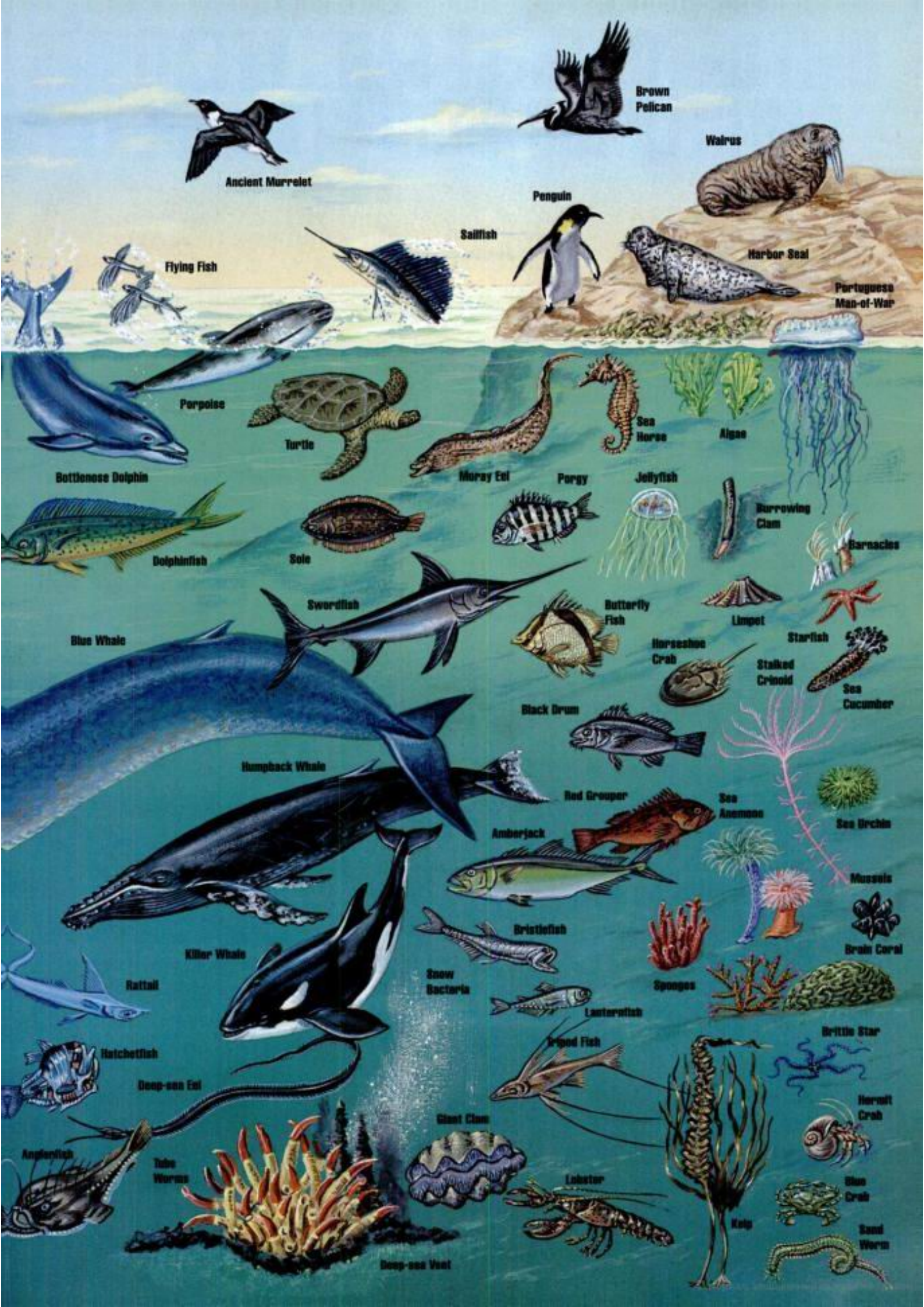
Globefish



By Robert Langreth

The Diversity of the Sea

HOWARD S. FRIEDMAN



Ancient Murrelet

Brown Pelican

Walrus

Penguin

Sailfish

Harbor Seal

Portuguese Man-of-War

Flying Fish

Perpoise

Turtle

Muray Eel

Sea Horse

Algae

Bottlenose Dolphin

Dolphinfish

Sole

Porgy

Jellyfish

Burrowing Clam

Barnacles

Blue Whale

Swordfish

Butterfly Fish

Limpet

Starfish

Stalked Crinoid

Sea Cucumber

Black Drum

Horseshoe Crab

Humpback Whale

Red Grouper

Sea Anemone

Sea Urchin

Amberjack

Mussels

Killer Whale

Bristlefish

Brain Coral

Rattail

Snow Bacteria

Lanternfish

Sponges

Brittle Star

Hatchetfish

Deep-sea Eel

Giant Clam

Winged Fish

Hermit Crab

Anglerfish

Tube Worms

Lobster

Blue Crab

Deep-sea Vent

Kelp

Sand Worm

DADDY LONG LEGS shuffles along with a majestic gait on four telescoping legs, avoiding the throngs of pedestrians at sidewalk level. While it offers a commanding view ahead at full extension, it can also stoop to avoid head-banging altercations with overhanging branches.



HEY! YOU TAKE THE WHEEL goes beyond the drive-by-wire concept, combining turning, accelerating, and braking into a single wireless remote-control module that replaces the steering wheel. How do you keep it from being stolen by roving joy riders? When you park, take the steering wheel with you.

In Toyota's Idea Expo vehicle competition, teams are disqualified for being too serious or practical.

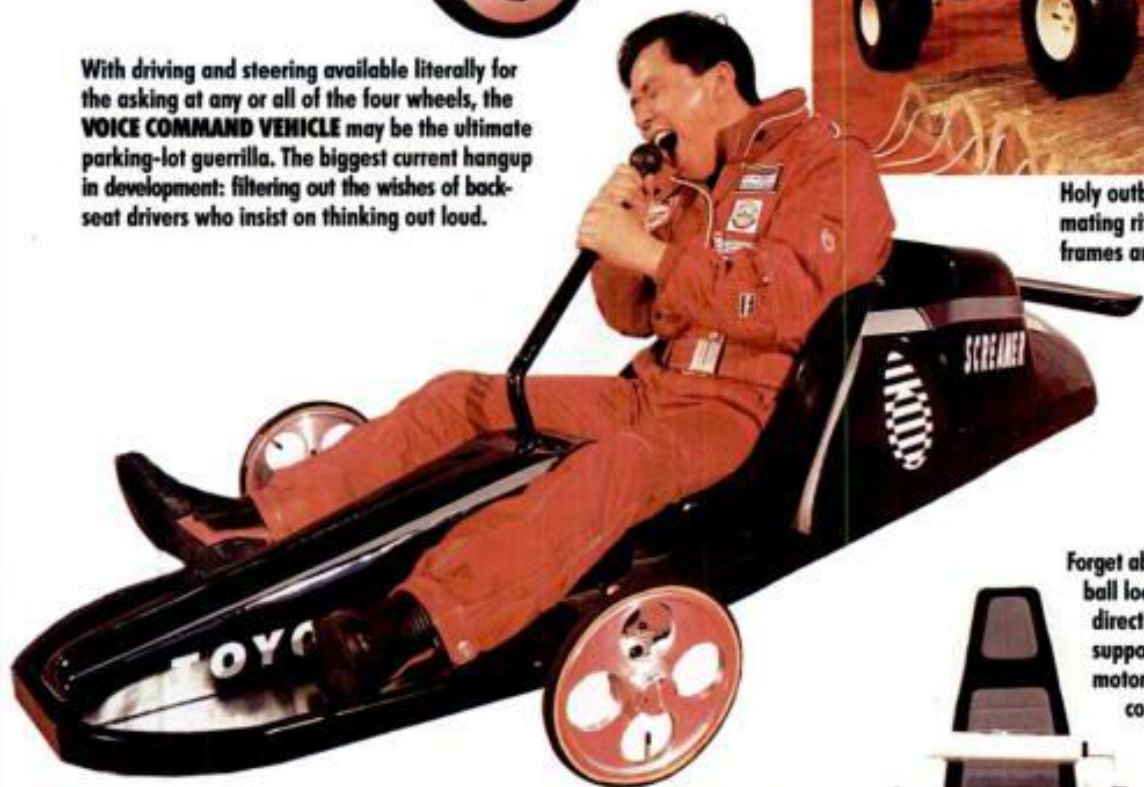
FUNNY



With driving and steering available literally for the asking at any or all of the four wheels, the **VOICE COMMAND VEHICLE** may be the ultimate parking-lot guerrilla. The biggest current hangup in development: filtering out the wishes of back-seat drivers who insist on thinking out loud.



Holy outback, Martha! It's the rarely seen mating ritual of all-terrain vehicles! With two frames and nine wheels, the **NEW WALKER** leaptfrogs one set of wheels at a time to amble over obstacles or turn in its own length.



Noise pollution emitted by gridlocked drivers is converted to useful energy by the **SCREAMER**, a single-seater that regulates speed entirely by the volume of the driver's voice. It works equally well in all languages, but self-control is strongly advised.

Forget about all-wheel drive, we've got bowling-ball locomotion here! **TETRA** scoots in any direction on motor-driven spheres. A trio of support arms and fully independent drive motors eliminate the need for any sort of conventional steering mechanism.



CARS

I've always figured that if you told a group of car engineers to put all seriousness aside, they'd end up drawing computer-generated happy faces on their pocket protectors. The winning entrants in a contest for Toyota engineers and technicians disprove my theory, though, with high-smileage alternatives to everyday transportation. Toyota sponsors the contest to encourage its engineers to stretch their imagination.—Norman S. Mayersohn

EARTH, MY LOVE

Giant rubber bands store energy generated by photovoltaic cells in this environmentally friendly vehicle. An electric motor winds them up.



THE CLEAN ENERGY CAR

This vehicle's only emissions are oxygen and water; it's powered by a chemical reaction.



THEY JUMP THEY SPIN THEY RUN ON RUBBER BANDS

**Rube Goldberg
would have
been proud**

BY DENNIS NORMILE



A Venetian gondola that travels on dry land? A car powered by rubber bands? A commuter car that converts to a personal monorail vehicle? It could only be the Toyota Engineering Society's annual Idea Olympics ("Funny Cars," July '90; "Automotive Newsfront," March '91). Once again, society members have stretched their imaginations and their engineering expertise by devising improbable vehicles. But this year, even though it's all for fun, environmental interests are reflected in many of the entries.

"We're concerned about traffic jams, increasing traffic accidents, and environmental problems," explains Takeo Kurokawa, spokesperson for the team that put together Vehicle Skyner.

Much more than a car, Vehicle Skyner is a proposal for an entire transportation system. Individual electric cars would run on roads outside city centers but convert to personal monorail cars for travel downtown where a light monorail system would be strung from building to building.

The prototype is a two-wheeled vehicle with small rollers on winglike protrusions for stability on conventional roads.



THE DELTA BEETLE

Two electric motors—one powering the triangular wheels, the other driving the tractor treads—make this car appear to be moving forward while it is actually backing up.



HAZUMU

Three sets of air pistons and springs let it jump—or dance—to its destination.

MOON WALK BICYCLE

Two levers control this pedaled vehicle's motion. With both forward, it moves forward; with both back, it moves backward; with one lever forward and one back, it spins.

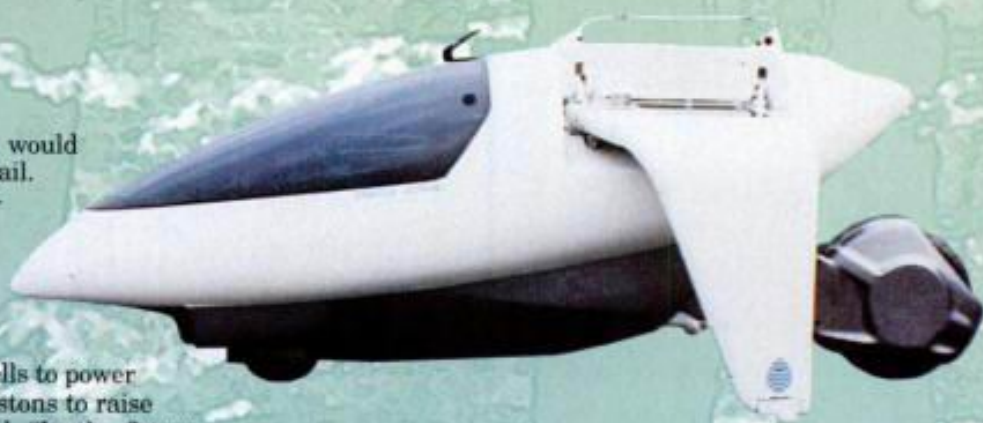


At a monorail entry station, the wings would swing up, allowing rollers to grasp the rail. Then the drive wheel at the rear of the vehicle would swivel up to run against the rail's bottom flange. The same drive-train powers the car on streets and on the rail.

Power comes from conventional lead-acid batteries, but the car also has solar cells to power the controls. Compressed air drives the pistons to raise and lower the wings and the drive wheel. "In the future, maybe it could all be solar," says team member Tsuyoshi Yamazaki.

Another vehicle, the Clean Energy Car, takes a new approach to producing power. Instead of burning a fuel, it re-

(Continued on page 94)



VEHICLE SKYNER

More than a car, it's designed as a complete transportation system. The electric vehicle would be driven on roads or on a light monorail guideway.

The Newest Way

With the most powerful jet engines ever built, the Boeing 777 is ready for takeoff.

BY
DAWN
STOVER

The 87-foot-high doors of the world's largest building opened on April 9, and out of a cavernous bay rolled the first Boeing 777. Scheduled to

make its maiden flight this month, the 777 is the biggest twin-engine jetliner made, and it sports the most powerful jet engines ever built.

From the outside, the 777 looks similar to today's jetliners. Inside, passengers will notice a difference. The fuselage is more than 20 feet in diameter—only the giant 747 has a wider interior. And because the side walls are not as sharply contoured as those of other wide-body planes, passengers in the window seats will have more headroom. The customers who helped Boeing plan the 777—United Airlines, All Nippon Airways, Japan Airlines, and British Airways—insisted on spaciousness and other features that make the cabin more adaptable than in earlier models.

Built at a Boeing factory that covers more than 98 acres in Everett, Wash., the 777 incorporates the latest in computerized flight-control technology and high-efficiency fan-jet engines. The new airliner will carry 305 to 328 passengers in a three-class seating arrangement—filling the niche between the company's 218-passenger 767 model and the 420-passenger 747.

Large twinjets are popular with airlines because they use less fuel per passenger and require less maintenance than three- or four-engine aircraft do. But getting a plane the size of the 777 off the ground takes a lot of power. Three competing manufacturers have risen to the challenge and developed monster engines for the 777: the Pratt & Whitney PW4000, the General Electric GE90, and Rolls-Royce's Trent 800. So far, seven airlines have chosen the GE90 engine, while four airlines have each chosen one of the other two.

The new engines produce thrust of more than 80,000

pounds each. By comparison, the most powerful engines on the 747 produce about 60,000 pounds of thrust. All three of the 777 engine models are high-bypass turbofans that use a large, wide-bladed front fan to push massive quantities of air, only a small fraction of which passes through the powerplant's turbine core. These efficient engines are essentially turbine-driven ducted propellers. And they are big. The diameter of the GE90 engine's nacelle, for example, is about the same as the entire fuselage of a 757 airliner.

The 777 will be Boeing's first airliner using the "fly-by-wire" flight-control technology first adopted by the European Airbus consortium. The pilot's corrections are transmitted to the rudder, flaps, and other control surfaces electronically, rather than mechanically, after passing through a computer that generates the actual commands. The signals travel along simple twisted pairs of wires connected by vibration-tolerant inductive couplers that snap in place and interrogate the lines for the data flowing through them.

A feature called "fault tolerance" is built into the system. It was originally developed by the Air Force, which is interested in making combat-damaged fighters able to limp safely home. Should a 777 component such as a hydraulic flight-control actuator fail, the computer automatically reroutes its commands to an appropriate combination of control surfaces to keep the airliner stable and flyable. Three parallel fly-by-wire computer systems provide two

[Continued on page 104]

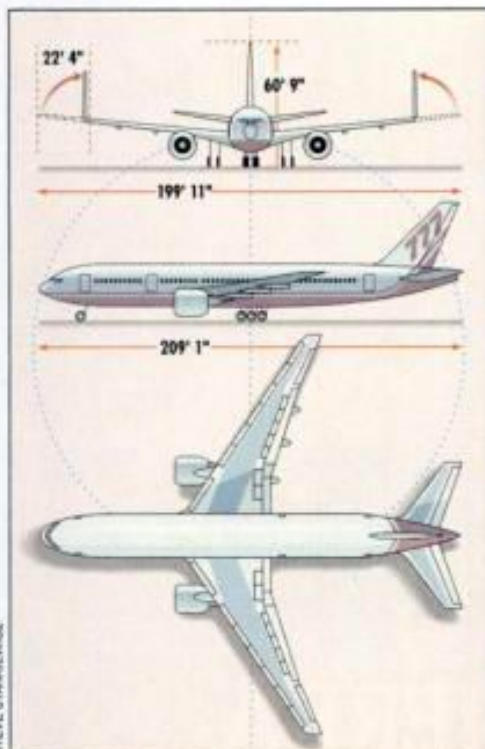


To Fly



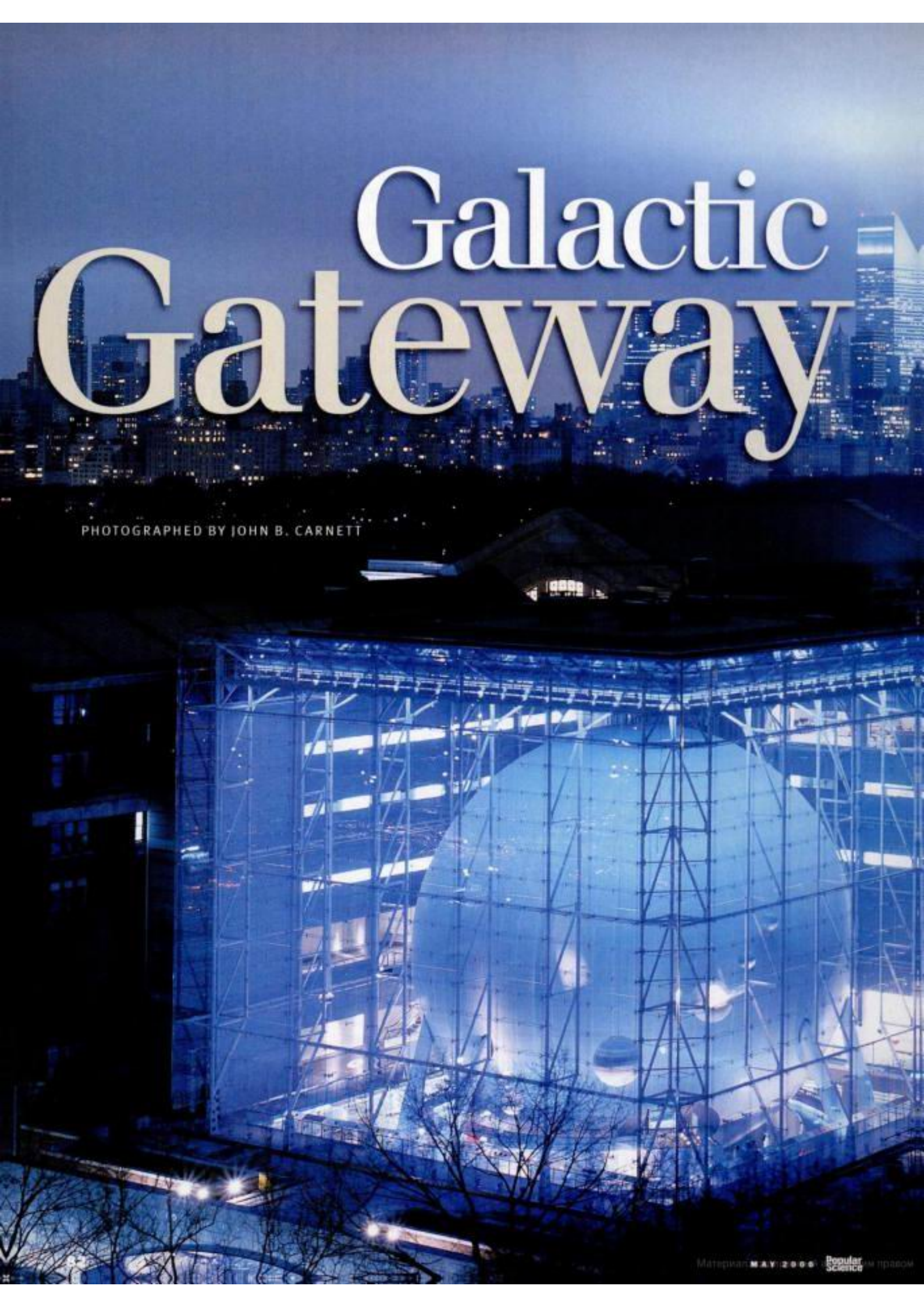
TOUR OF THE 777

1. New 777 fanjet engines, built by three different manufacturers, are as quiet as those on the twinjet Boeing 767, but produce 40 percent more power.
2. Boeing offers optional folding wingtips that help the 777 squeeze into small airport departure gates, but no airlines have ordered this feature.
3. With a wider body than any jetliner except the Boeing 747, the 777 will provide three-class seating for 305 to 328 passengers, or two-class seating for 375 to 400 passengers.
4. Resistant to corrosion and fatigue, lightweight composite materials replace metals in the tail assembly and floor beams of the aircraft's passenger cabin.
5. The main landing gear has two six-wheel trucks, instead of conventional four-wheel units, for better weight distribution on runways.
6. "Flexibility zones" near the four doors allow airlines to move galleys and lavatories, reconfiguring the plane for different routes and seasons.

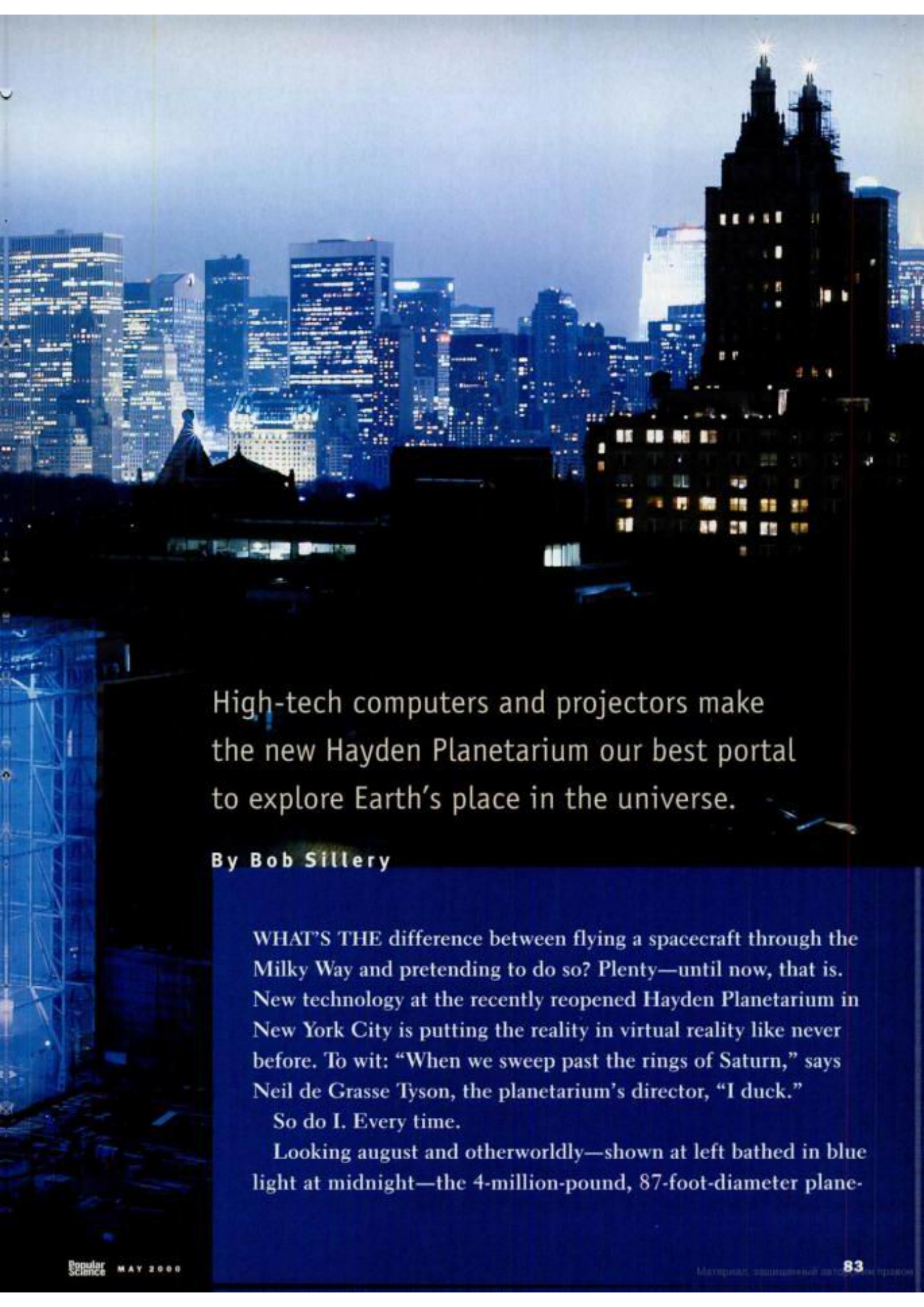


The drawings above (left) show the shape and dimensions of the 777. The flight deck (right) has a horizontal layout similar to that of the Boeing 747. Cathode-ray tubes have been replaced with lightweight liquid-crystal displays that save space and power and remain clearly visible in direct sunlight.

Galactic Gateway



PHOTOGRAPHED BY JOHN B. CARNETT



High-tech computers and projectors make the new Hayden Planetarium our best portal to explore Earth's place in the universe.

By Bob Sillery

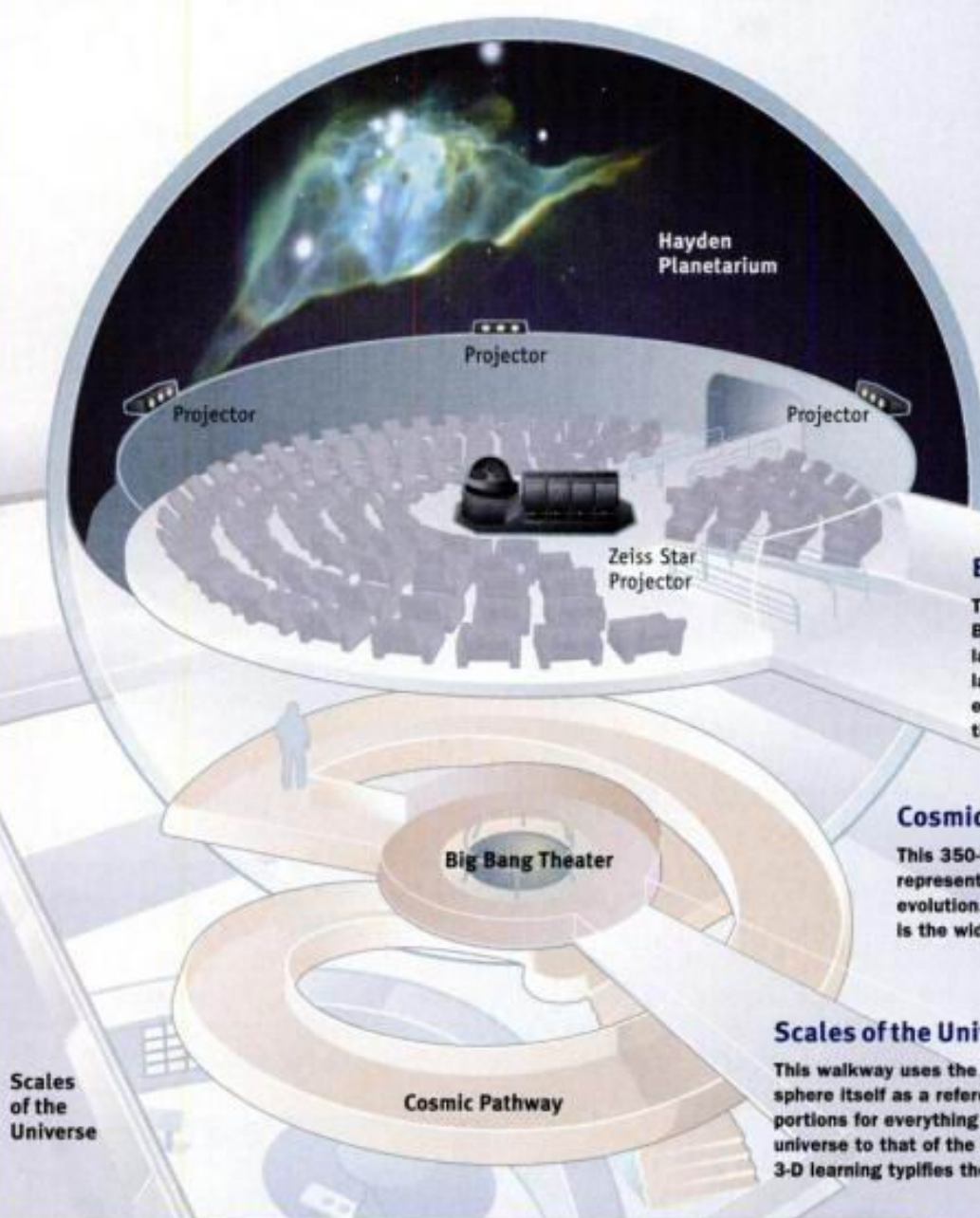
WHAT'S THE difference between flying a spacecraft through the Milky Way and pretending to do so? Plenty—until now, that is. New technology at the recently reopened Hayden Planetarium in New York City is putting the reality in virtual reality like never before. To wit: “When we sweep past the rings of Saturn,” says Neil de Grasse Tyson, the planetarium’s director, “I duck.”

So do I. Every time.

Looking august and otherworldly—shown at left bathed in blue light at midnight—the 4-million-pound, 87-foot-diameter plane-

Unveiling the Rose Center

THE ROSE CENTER for Earth and Space at the American Museum of Natural History comprises the Hall of the Universe—with its crown jewel, the new spherical Hayden Planetarium—and the Hall of Planet Earth (not shown), which opened in 1999.



Hayden Planetarium

At the planetarium's Space Theater, scientists and artists have modeled the latest astronomical data into a 3-D, high-definition 20-minute trip through the universe that's projected onto the planetarium's dome. The Zeiss Star Projector (below) captures the majesty of the night sky. Then, controlled by a Silicon Graphics super-computer, seven high-power projectors simulate flight through the stars.



Big Bang Theater

The bottom half of the sphere houses the Big Bang Theater. Visitors look down into a large bowl on the inverted dome for a simulation of the birth of the universe. Rumbling effects accompany rushing, swirling sensations as pent-up forces explode.

Cosmic Pathway

This 350-foot ramp, with 220 images, represents 13 billion years of cosmic evolution. The period of human history is the width of a strand of hair.

Scales of the Universe

This walkway uses the size of the Hayden sphere itself as a reference to create proportions for everything from the size of the universe to that of the atom. This immersive 3-D learning typifies the entire Rose Center.



Rendering the Orion Nebula To reproduce the nebula's data-intensive luminescence, wispy gas and dust, and other components in *Passport to the Universe*, the museum teamed with the San Diego Supercomputer Center.

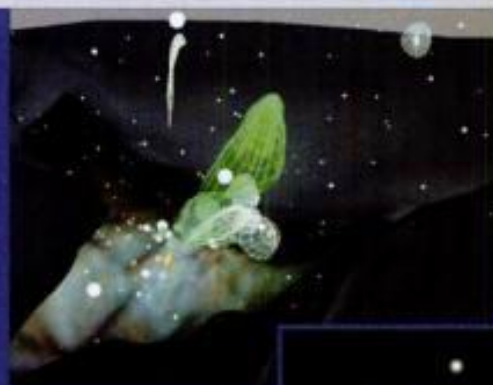


1 The process began with a two-dimensional image taken by the Hubble Space Telescope. Because of the reddening and obscuring effects of interplanetary dust, the image was digitally corrected.



2 Based on previous research, scientists were able to infer the topography of the nebula, giving it height and depth. About 90 sublayers were then added to the rendering.

3 Using 3-D models of each component, researchers added a third dimension (above). Then working with 3-D pixels, or voxels, a supercomputer generated 28,000 high-resolution images for the fly-through (right).



New age for airships?

Workhorse copter-blimp



SIX-MINUTE RIDE INTO SPACE



X-15 Pilot Scott Crossfield

Here's what it will be like to rocket more than 100 miles into the sky. The X-15, our first manned space vehicle, is scheduled for its epochal climb early in 1959

By Richard F. Dempewolff

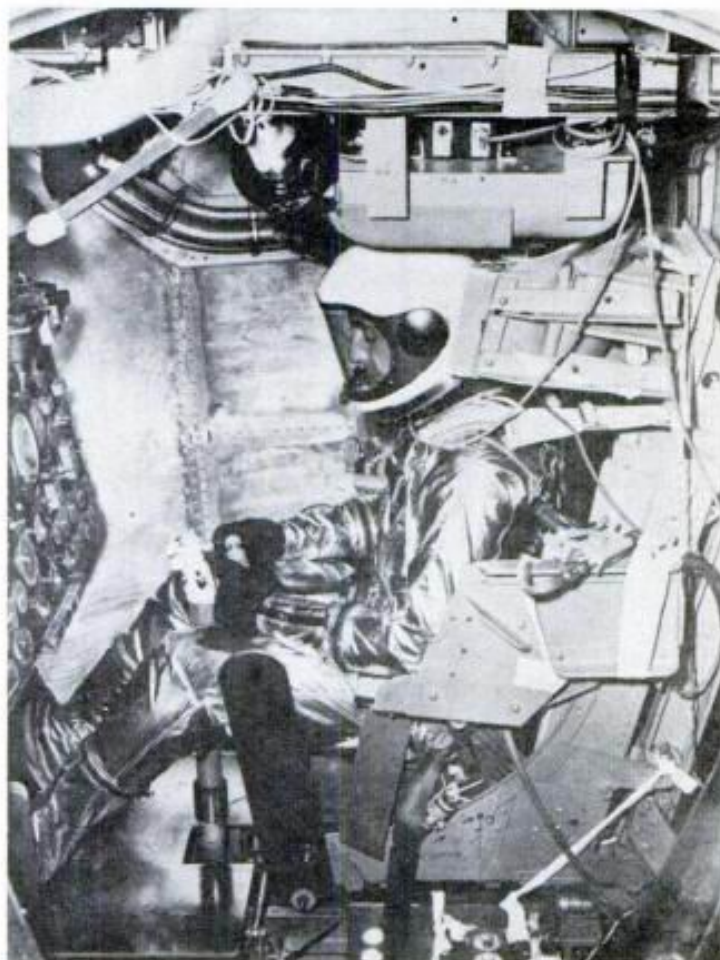
WHEN TEST PILOT Scott Crossfield of North American Aviation, buckles on the 4000-mile-per-hour X-15 "space research" plane for its first trial flight, he will be wearing the most fantastic "outer garment" ever tailored for a human being. Seen by the public for the first time a few weeks ago, when it rolled out on North American's ramps in El Segundo, Calif., the gleaming aircraft looked exactly like what it really is — a man-carrying, recoverable ballistic rocket.

More than 50 feet long, with 22-foot wingspan, the 31,275-pound ship has a unique wedge-shaped bulge along each side. Inside these sweeping finlike appendages of beryllium (to resist friction heat), are all the control cables, wires, hydraulic plumbing and lines. The fuselage itself, behind the pilot, is fully occupied by the big 60,000-pound-thrust XLR-99-RMI jet engine, capable of multiple air starting and variable thrust, and by massive tanks—one for gas-generating fuel, and two for necessary tons of explosive fuel components for the engine: Liquid oxygen and ammonia. More than half the fat fuselage (four feet across at the tail) is occupied by the massive cylinders for these liquids. Special forward-tilting, dish-shaped baffles inside them will prevent "surging," which could throw the ship off balance and send it flipping through space like a leaf in a gale.

Early in 1959, the wicked-looking vehicle is scheduled for a series of hair-raising flights. Its human pilot will be encased in an alumi-

nized-fabric "space" pressure suit and lashed to a form-fitting seat in a cramped, insulated and refrigerated cockpit. Once the X-15 is dropped from the underbelly of a B-52 some six miles in the sky, he'll flick an ignition switch and jam back into his seat as the single-barrel rocket engine behind him explodes into life and gives

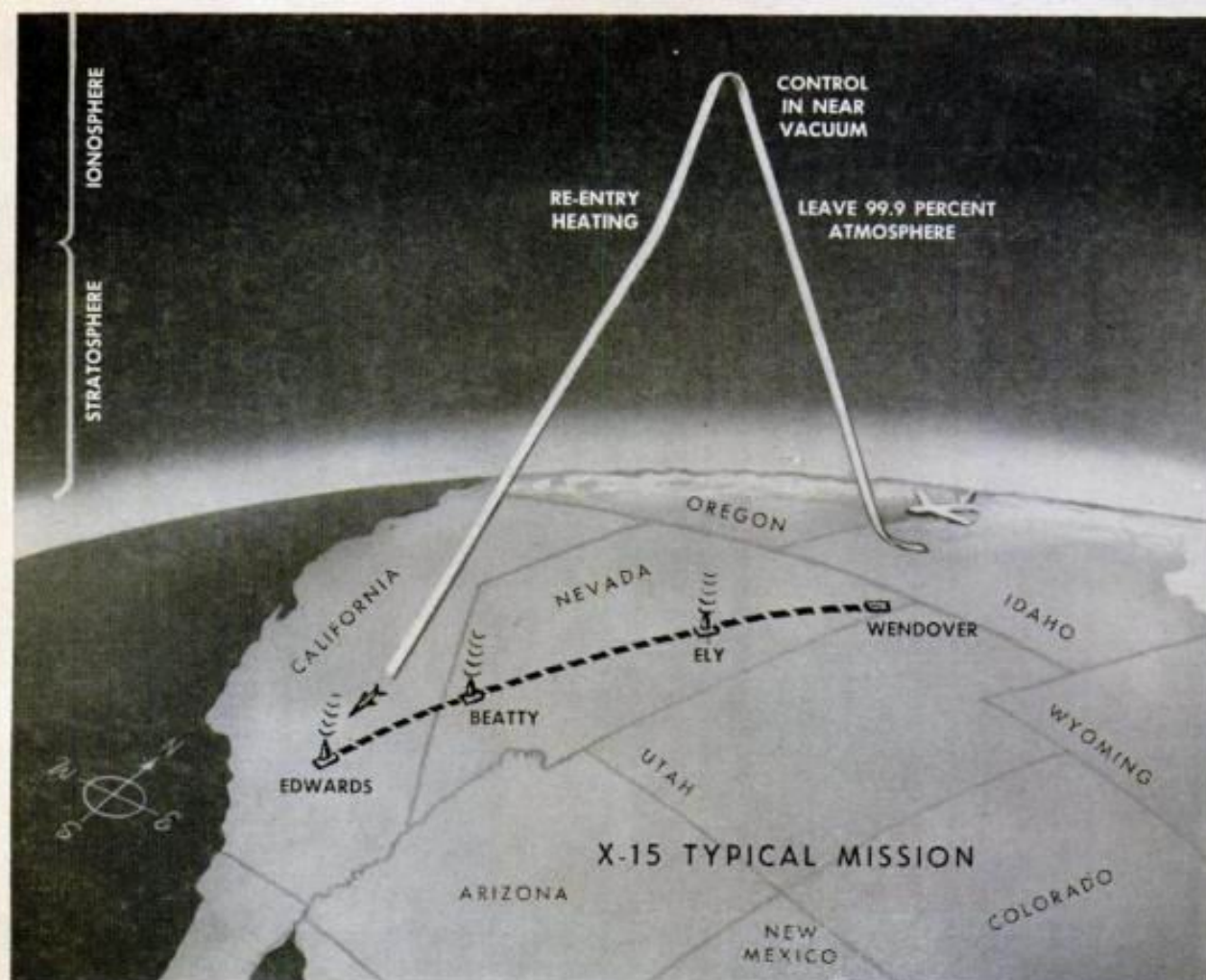
For more than a year, Crossfield has made simulated flights in a giant centrifuge equipped with an X-15 control panel



chunky wings, set far back on the fuselage, spread like a pair of goodly oak stumps in order to stay put under the incredible buffeting they'll get as the ship bursts through the atmosphere going and coming. Roots end in five A-frames that bolt solidly to the fuselage. Tail surfaces look more like thick, wedge-shaped doors for a bank safe than delicate control surfaces. Instead of a pair of horizontal stabilizers and a single vertical-rudder fin, X-15 has four tailfins—just as a good rocket should. The stabilizers slope downward like the wings of a gull taking off. The fourth member is a vertical fin jutting downward beneath the elevators. This fin will be jettisoned just before landing. The empennage is of the "flying tail" type, so-called because each tail surface (except the under fin) turns as a unit for steering in the thin upper air. This

(Continued to page 246)

Shown below is the pattern that Scott Crossfield is scheduled to fly early next year in the X-15. His plane, right, may transport him at speeds of 4000 miles per hour

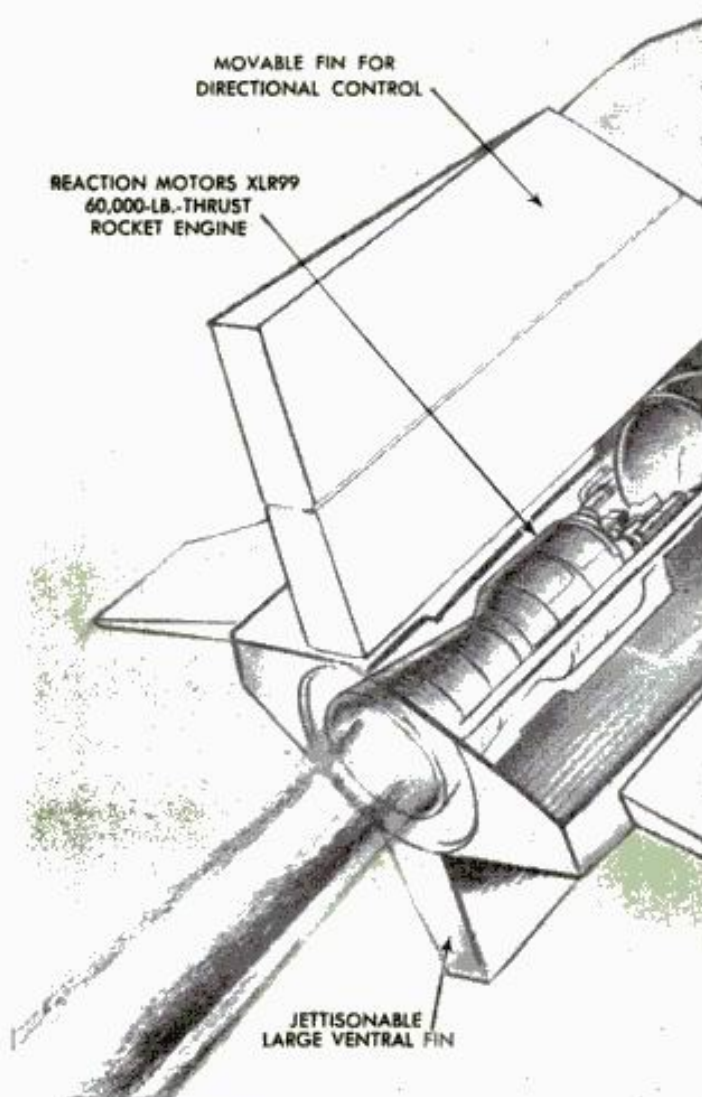
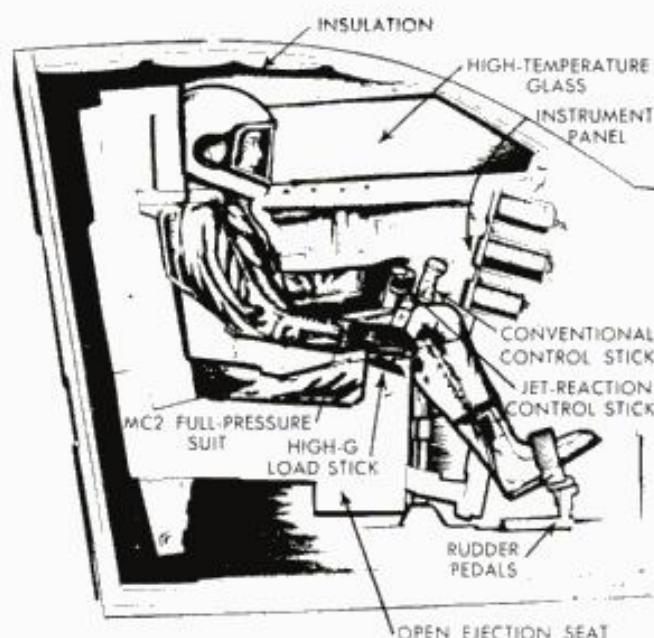


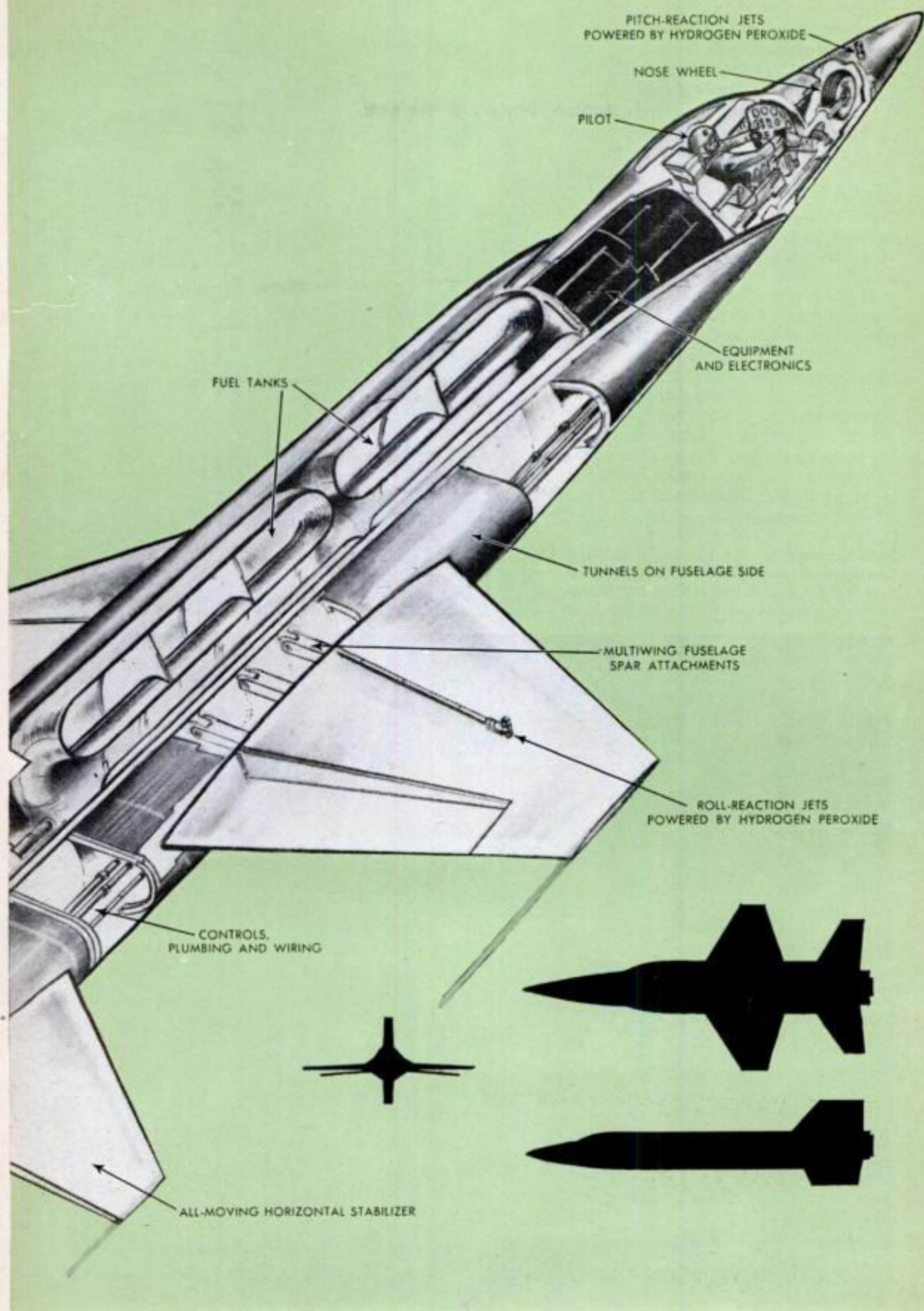
him a 60,000-pound "kick in the pants." With his face sagging and heart laboring to pump blood as heavy as molten metal, a 150-pound man like Crossfield will suddenly weigh 600 pounds as he roars vertically upward on a scorching column of blue shock waves for a total of six minutes of powered flight. At Mach 6 plus (4000 miles per hour or better), he will be rammed to an altitude of considerably more than 100 miles. Crossing the perigee tracks of the manmade satellites, he will skim the fringes of outer space in a weightless state for about five minutes as his craft arcs over into a powerless glide and plummets earthward. As he plunges back into the atmosphere, the skin of his rocket spaceship will, according to Air Force experts, "glow red like steel in a blacksmith's forge" along the leading edges of the stub wings and around the bluntly pointed nose. Skin temperatures will soar to 1000 degrees Fahrenheit. Some 500 miles after starting above Wendover Field, Utah, and 18 minutes later, the X-15 will skid to a smoky 284-mile-per-hour landing, probably on a dry lake bottom somewhere in the desert. It will land on steel shoes attached to short struts that pop out of the after-fuselage section. A conventional nose wheel will keep it from turning turtle. If all goes well, the X-15 will make many such trips under the guidance of a group of "hot" test pilots who have been training for the job for more than a year: Scott Crossfield and Alvin White for North American (builder of the plane;) Joseph Walker and Neil Armstrong, test pilots for NASA (National Aeronautics and Space Administration; formerly NACA); and captains Robert White and Robert Rushworth for the Air Force, which is supplying most of the estimated \$100,000,000 for the program.

No One Knows What Will Happen

The new research plane, along with two others like it now under construction, is our first manned space probe, a combined effort of the Air Force, Navy, NASA and U. S. industry. Its primary mission is to explore the myriad problems of spaceflight. These include things such as stability and controllability of the rocket ship. Nobody knows what will happen to a man-guided craft at hypersonic speeds within or outside the earth's atmosphere. What effect will the searing plunge into the earth's atmosphere have on ship and pilot? This will be the first time any man has been subjected to the inferno of re-entry friction. The effects of sustained weightlessness also will get a good going over.

To do its pioneering job, the X-15's design is, of necessity, a far cry from the general concept of an "airplane." Its thick







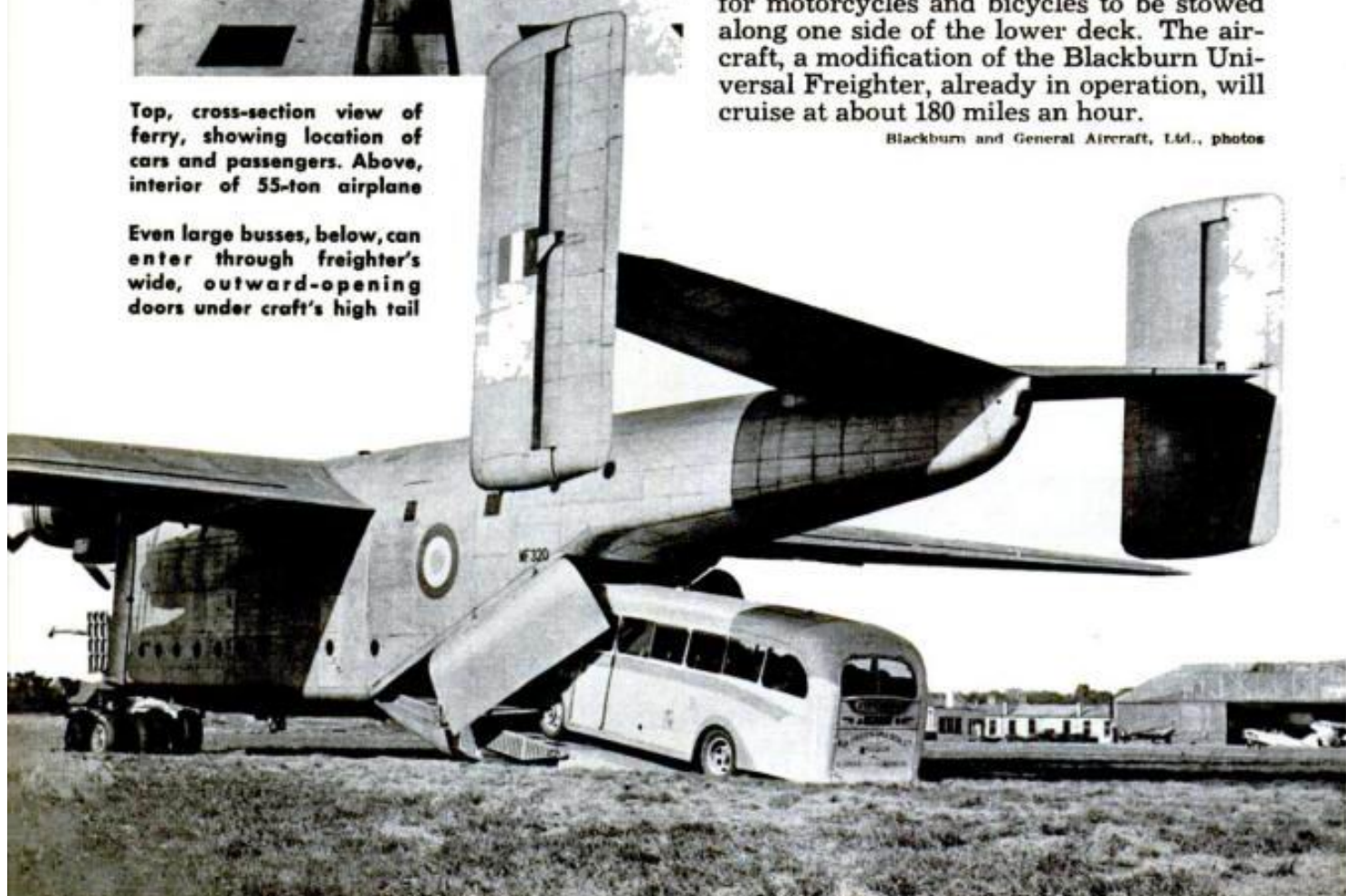
Top, cross-section view of ferry, showing location of cars and passengers. Above, interior of 55-ton airplane

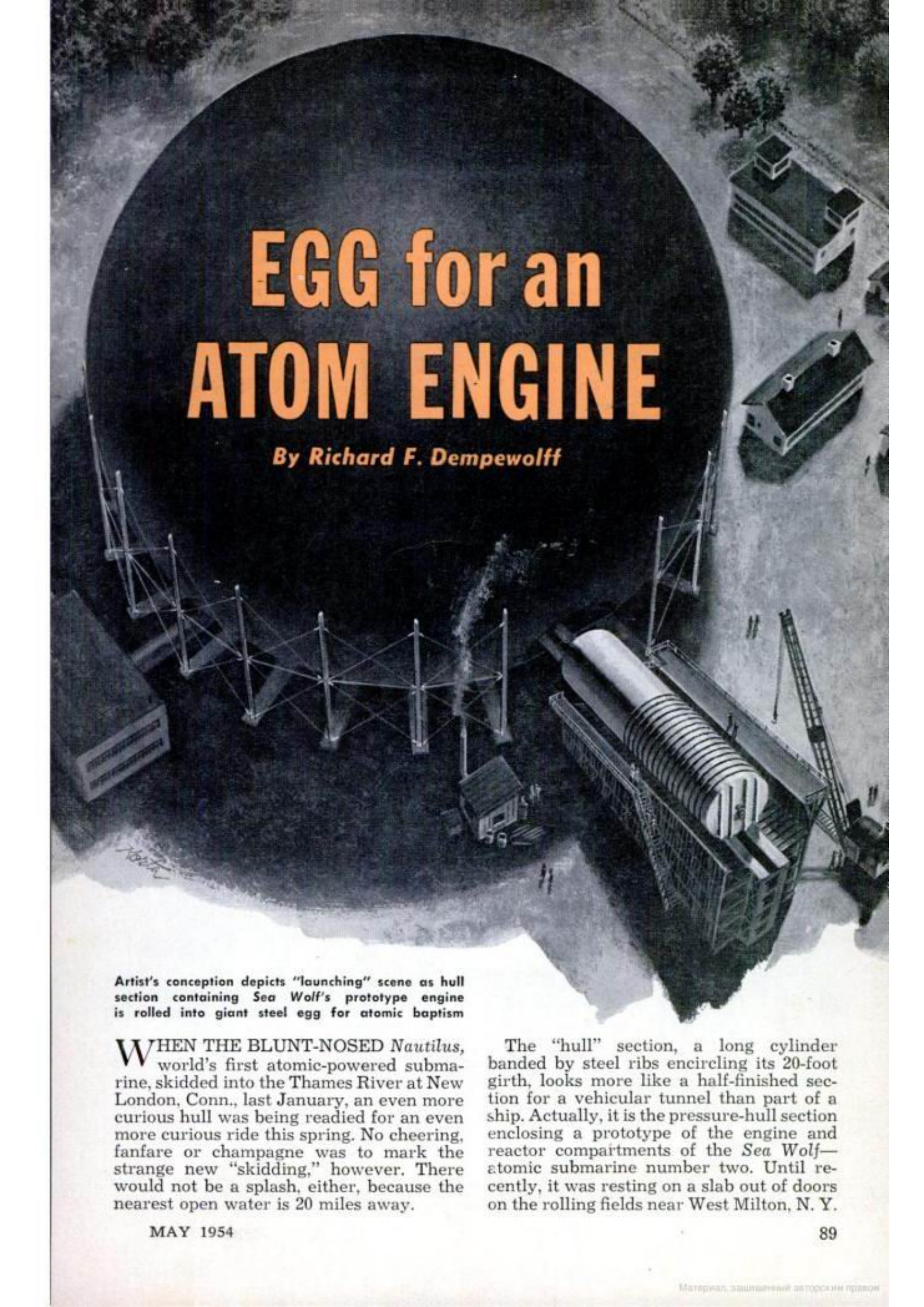
Even large busses, below, can enter through freighter's wide, outward-opening doors under craft's high tail

Car-and-Motorist Air Ferry For Cross-Channel Service

Up to 8 automobiles and 42 passengers will be carried on a triple-decker freighter airplane scheduled to begin flights in England next year. It will enable tourists to fly with their cars on ferry trips between the British Isles and Europe. The aircraft's two lower decks will house cars and other vehicles, with the passenger cabin and crew compartment occupying the third level. The cars will be loaded through two large doors at the rear of the four-engine, 55-ton aircraft, after being pulled singly up the ramp by a winch. An elevator will lift the first vehicles to the second deck where they will be slid forward on rails into position. All the cars will be locked in place for the flight. The complete loading operation for freight and passengers will take 20 to 25 minutes. There will be enough space for motorcycles and bicycles to be stowed along one side of the lower deck. The aircraft, a modification of the Blackburn Universal Freighter, already in operation, will cruise at about 180 miles an hour.

Blackburn and General Aircraft, Ltd., photos





EGG for an ATOM ENGINE

By Richard F. Dempewolff

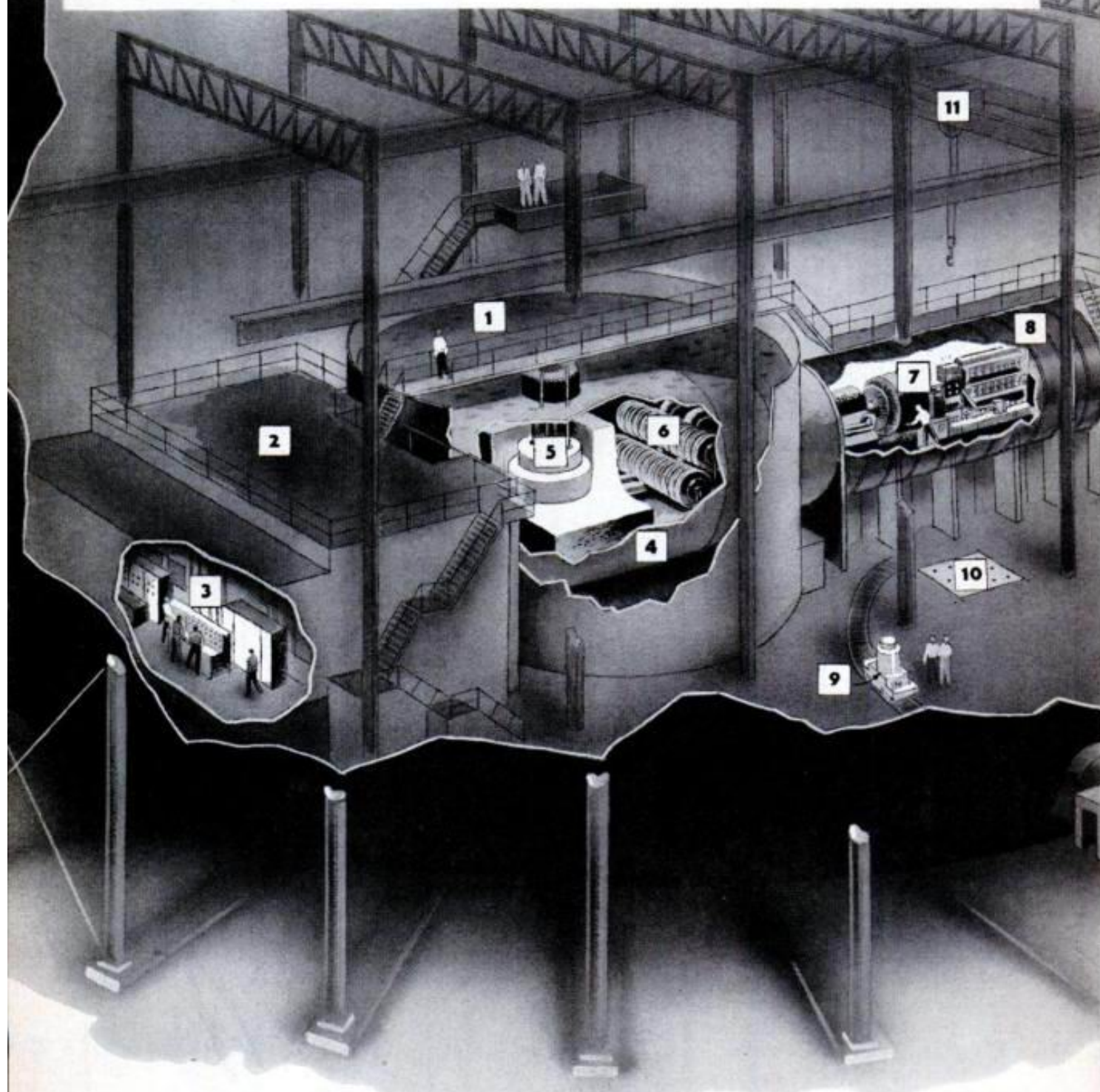
Artist's conception depicts "launching" scene as hull section containing *Sea Wolf's* prototype engine is rolled into giant steel egg for atomic baptism

WHEN THE BLUNT-NOSED *Nautilus*, world's first atomic-powered submarine, skidded into the Thames River at New London, Conn., last January, an even more curious hull was being readied for an even more curious ride this spring. No cheering, fanfare or champagne was to mark the strange new "skidding," however. There would not be a splash, either, because the nearest open water is 20 miles away.

The "hull" section, a long cylinder banded by steel ribs encircling its 20-foot girth, looks more like a half-finished section for a vehicular tunnel than part of a ship. Actually, it is the pressure-hull section enclosing a prototype of the engine and reactor compartments of the *Sea Wolf*—atomic submarine number two. Until recently, it was resting on a slab out of doors on the rolling fields near West Milton, N. Y.

Cutaway drawing of sphere, hull and fuel-service section shows water-filled tank (1) to shield the reactor, and cell (2) that holds liquid metal used as heat-exchange fluid. Also shown are the control panels (3), reactor section of hull (4), with the atomic pile (5). Molten sodium passes through the pile and heats water to steam in the boiler (6). The steam drives turbines (7) enclosed in the end section of pressure hull (8). Lead container for uranium rods (9) rides dolly to service cell. Near by is the fuel storage pit (10) and above is the traveling crane (11) for refueling and servicing. On the opposite page the fuel storage tunnel is shown below the fuel-element service cell which

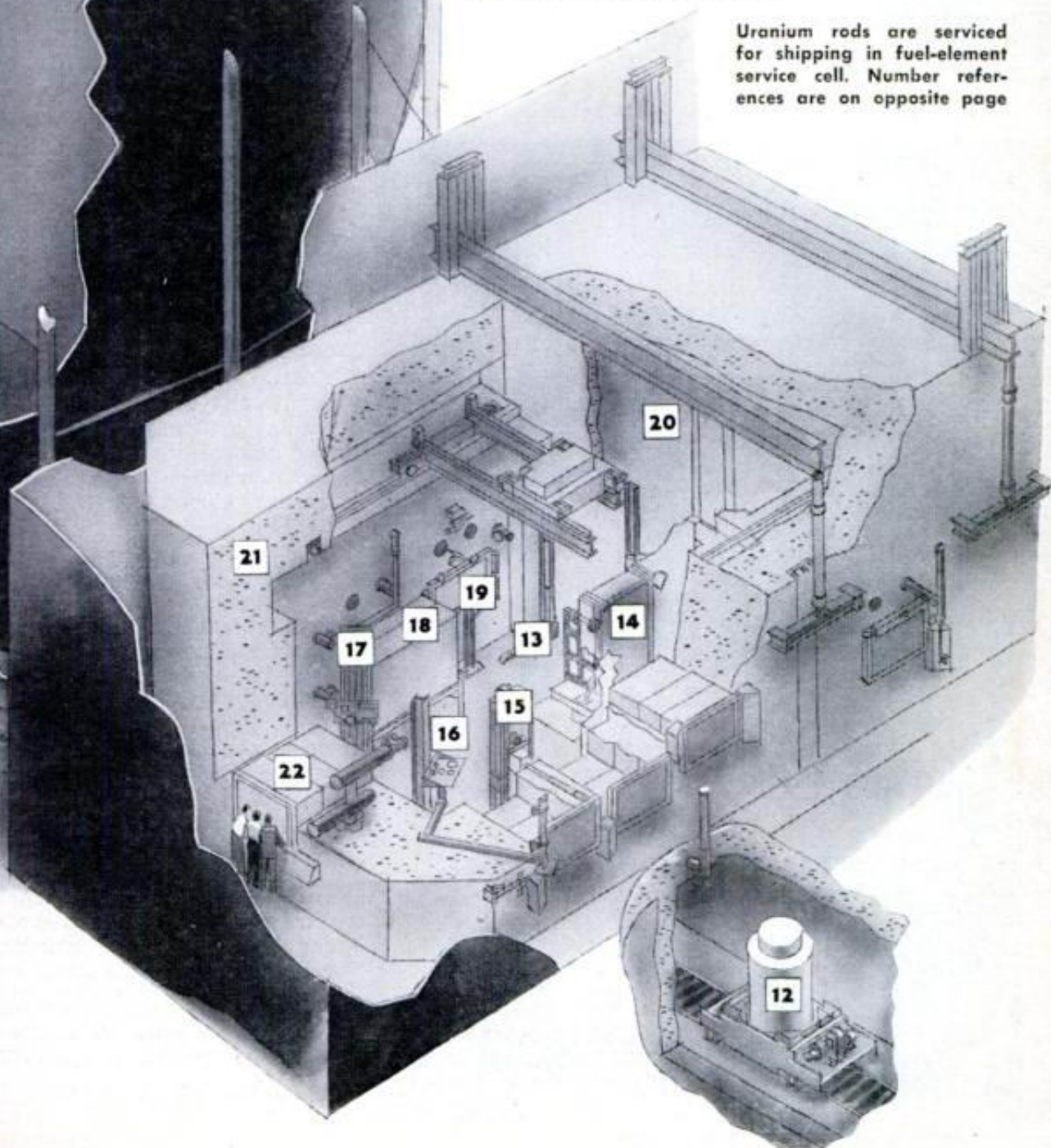
has massive concrete walls. Until needed the uranium rods are stowed in a heavy lead container (12) and pulled out of the tunnel through a hatchway by a mechanical hand (13) which passes them to cleaning station (14) where tons of water wash the rods. At scanning station (15) electric eyes examine them for flaws. Next stop is the inspection and measuring area (16). Robot hands (17) pull them apart and the rods pass to the sample cutting station (18) which chops off a chunk. At the adjoining station (19) "burned up" portion of rod is canned for shipment to a reprocessing center. Also shown are decontamination area (20), concrete walls (21) six feet thick, and shielded monitor station (22)

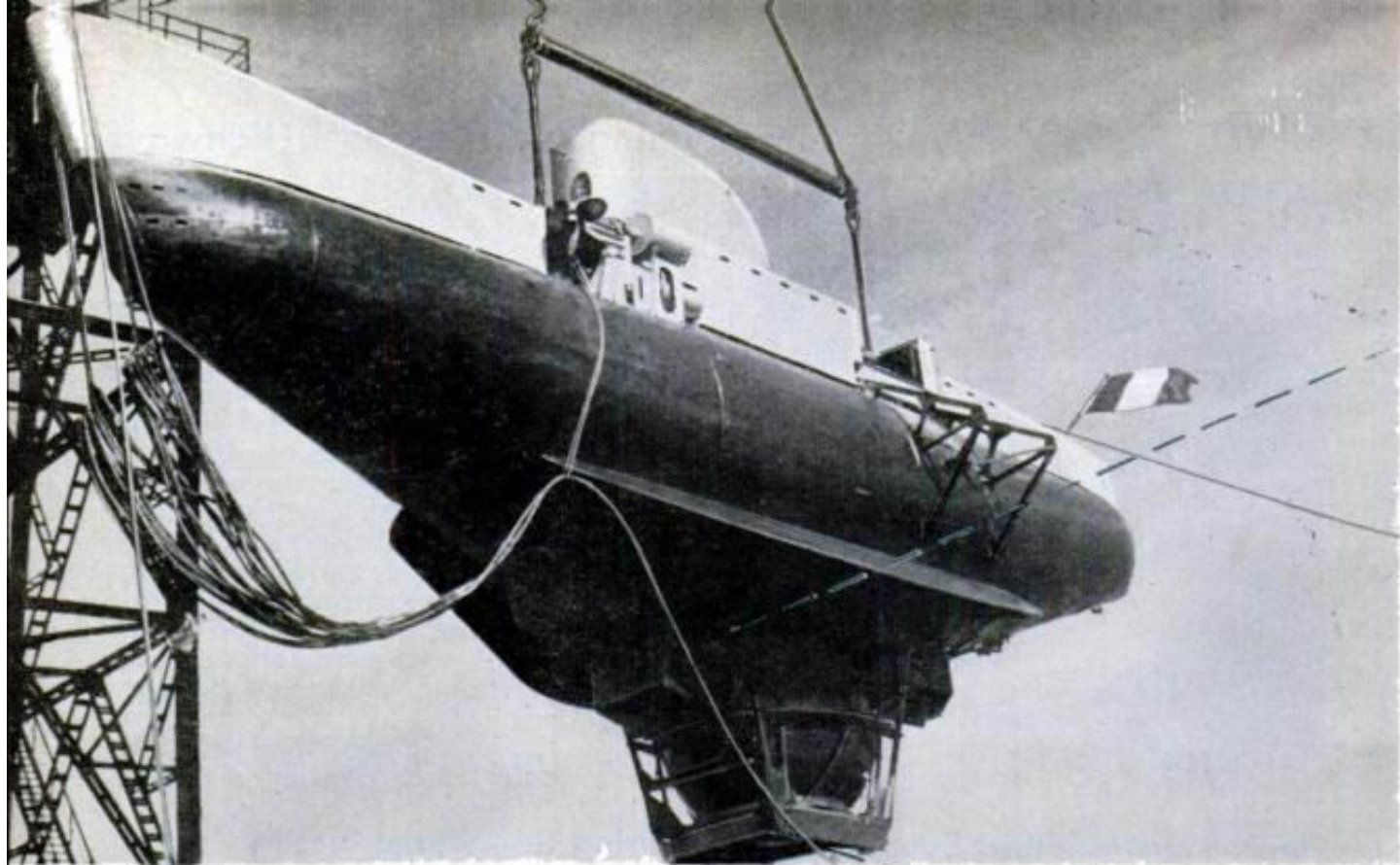


But, a few months ago, against a backdrop of empty land and sky, the odd hull rumbled slowly on steel rollers. It slid about 200 feet, through a hole in the curving wall of the world's biggest manmade ball—a \$2,000,000, 225-foot shell of steel that had been built close by to receive it. Welders swarmed in to seal up the hole, and a mantle of secrecy dropped over the great egg.

Inside the giant sphere, where during construction hollow echoes bounced 'round and 'round off the curving wall until they merged with an incessant background roar, General Electric Company scientists from KAPL (Knolls Atomic Power Laboratory) will install a new kind of atomic engine in the ribbed-hull section. A vast tank for water will be built around the reactor portion. "This," explains one scientist, "is not a big bathtub to simulate 'ocean conditions,' as many folks like to imagine. It's additional shielding to absorb any stray radiation from the reactor."

Uranium rods are serviced for shipping in fuel-element service cell. Number references are on opposite page





Bathyscaphe is lowered into ocean for test dive. Sphere on platform at bottom is the only watertight section

13,000 Feet Under the Sea In the French Bathyscaphe

SCIENCE REACHED new heights—or, more properly, depths—of exploration a few weeks ago when two French naval officers, manning one of the weirdest vessels ever constructed, plunged to a record depth of 13,284 feet under the sea. Called a bathyscaphe, it resembles a crude sub.

At midmorning the two men, Lt. Comdr. Georges Houot and Lt. Pierre Willm, dropped down through the conning tower and disappeared into a metal sphere fastened beneath the superstructure. Closing the hatch after them, they started the slow, vertical descent into the depths of the Atlantic off Dakar. No cable connected the vessel with the surface. About three hours later a guide rope beneath the bathyscaphe bumped the ocean floor, and the two men had set a new depth record for underwater exploration. Approximately two hours later they bobbed to the surface, determined to make other dives as soon as possible. The bathyscaphe is designed primarily for deep-sea research, and not just as a means of setting a new depth record.

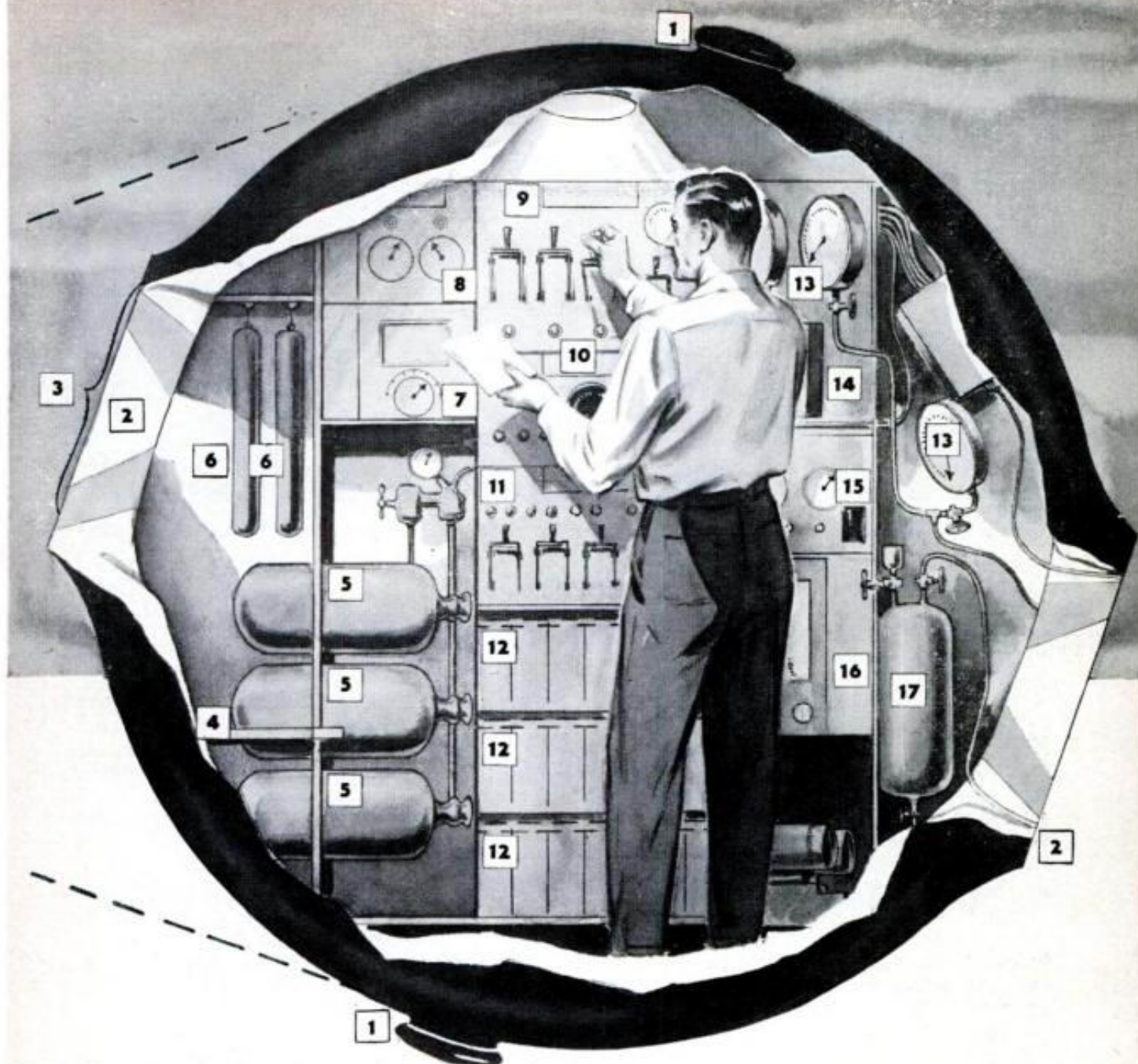
Actually the vessel is a free balloon in reverse. The only watertight portion is the steel sphere, designed to withstand a pressure of 5676 pounds per square inch. Most of the superstructure consists of tanks filled

with gasoline. An opening connects these tanks with the sea water, so the inside and outside pressures are virtually the same. Since the gasoline is lighter than water, it remains in the top of the tanks and provides buoyancy for the vessel.

When the men are ready for a dive they enter the sphere through a vertical lock. The lock then is filled with water, causing the bathyscaphe to sink. The farther it sinks the faster it descends because the gasoline is compressed by the sea water.

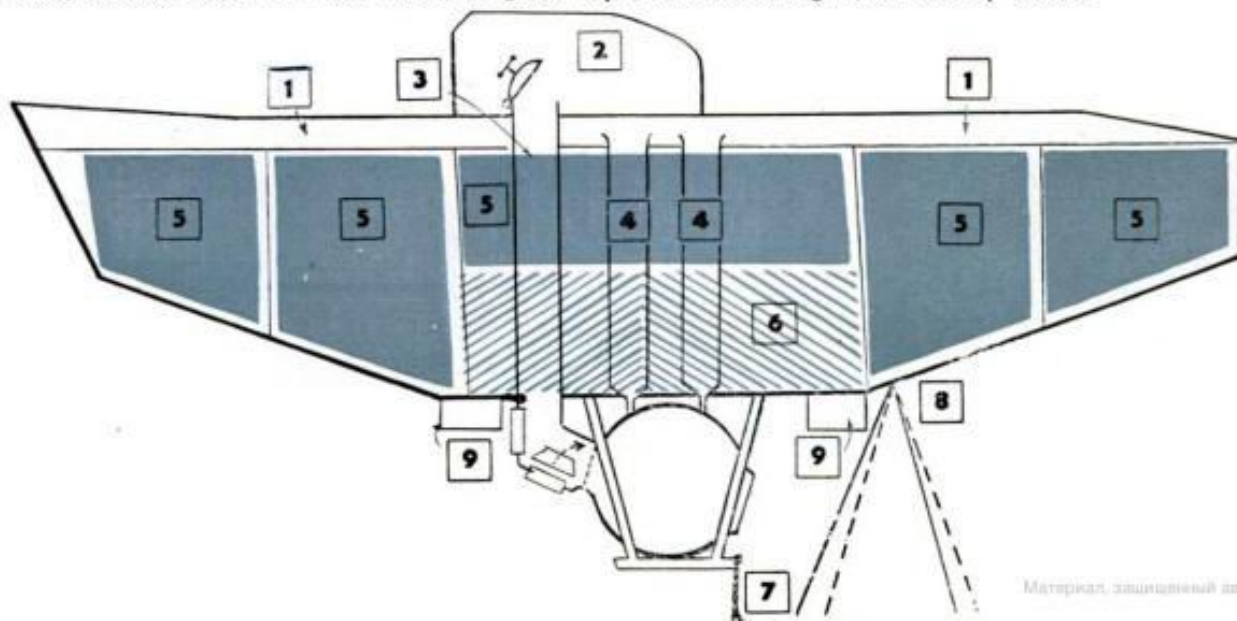
Aboard the vessel are four containers filled with iron shot. This ballast gives the men a means of controlling the rate of descent and also of returning to the surface. They throw magnetic switches which cause the iron pellets to pour slowly out of the containers, slowing the descent. When the divers are ready to leave the ocean bottom they dump more ballast until the bathyscaphe becomes lighter than the sea water (because of the gasoline) and begins to ascend. In this way the state of near equilibrium between the weight of the vessel and the buoyancy of the gasoline can be controlled.

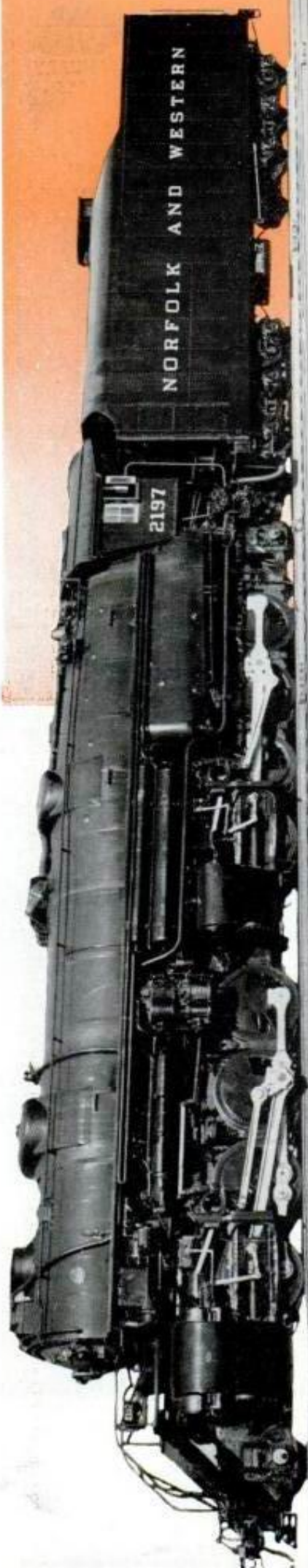
The greatest known ocean depth is 35,435 feet, and the men believe that depth can be reached in a bathyscaphe.



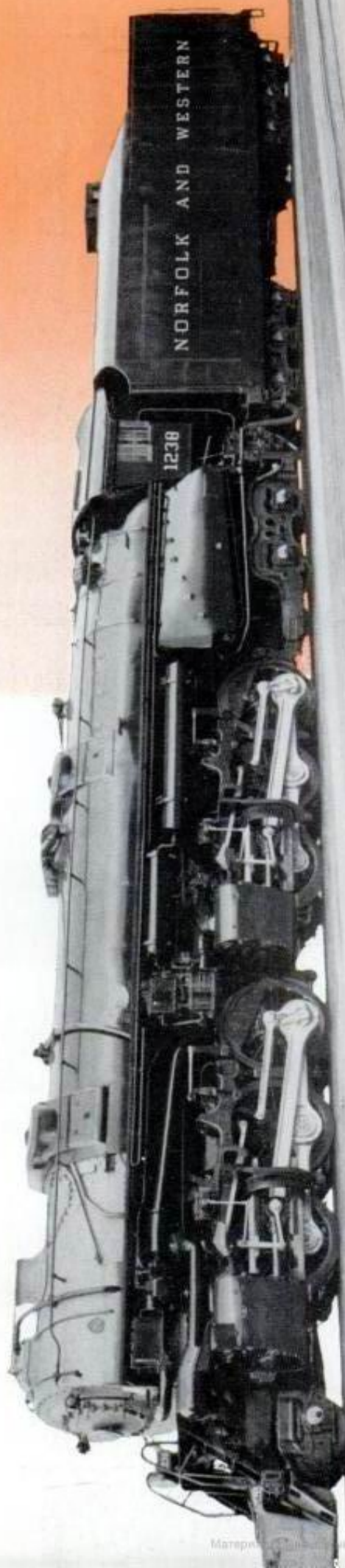
↑ 1. Clamps seal joints between hemispheres; 2. Portholes; 3. door; 4. entrance step; 5. oxygen bottles; 6. sodium carbonate, which absorbs carbon dioxide; 7. temperature gauges; 8. vertical compass; 9. electric switches; 10. shot gauges; 11. Ballast control; 13. pressure gauges; 14. automatic ballast release; 15. water-gasoline level gauge; 16. sounding instrument; 17. mechanism for sampling sea water

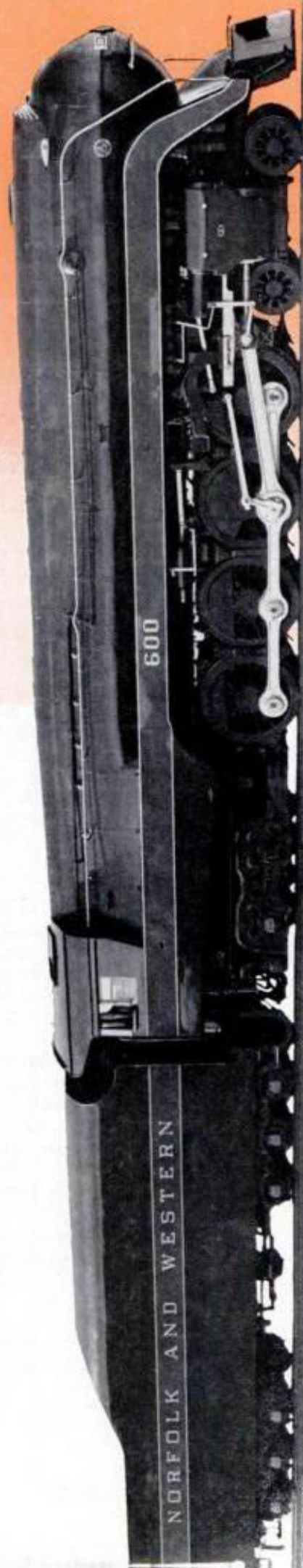
↓ 1. Nonwaterproof superstructure; 2. conning tower; 3. access hatch; 4. iron-shot containers; 5. gasoline tanks; 6. area filled with sea water; 7. guide rope; 8. exterior lights; 9. security ballast



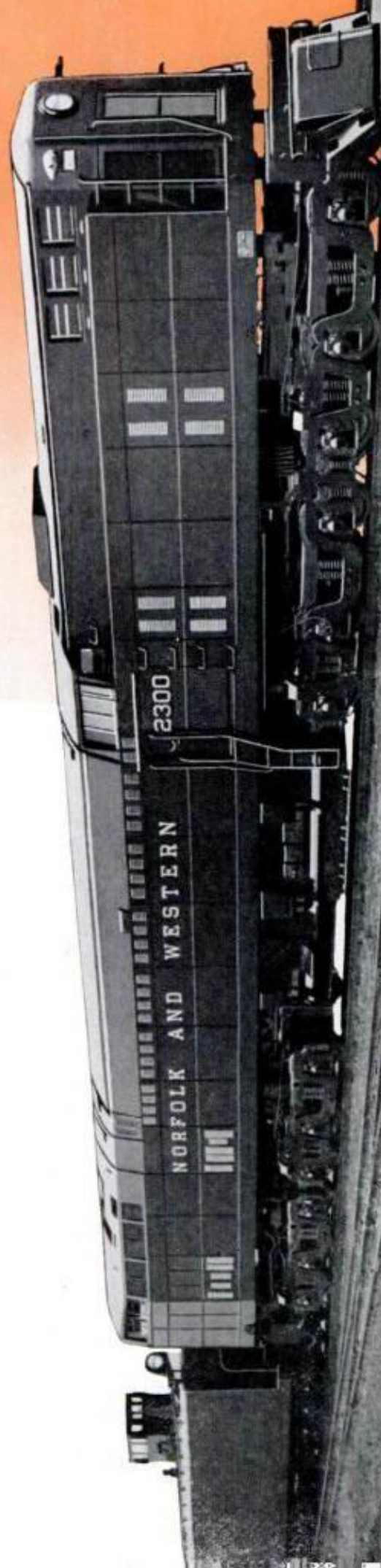


Norfolk and Western had some pretty-good-sized steam locomotives pounding its high iron before No. 2300 came along. But the big steam-turbo-electric job, with its 586-ton weight and 161-foot, 1½-inch length, puts them in the little-brother category. Former record-holders in the weight and length divisions were these articulated giants. The 2-8-8-2 Class Y6 (above) weighed 495 tons, while Class A 2-6-6-4 locomotives (below) were the road's longest, 121 feet, 9¼ inches. Both were made in N&W's own Roanoke shop

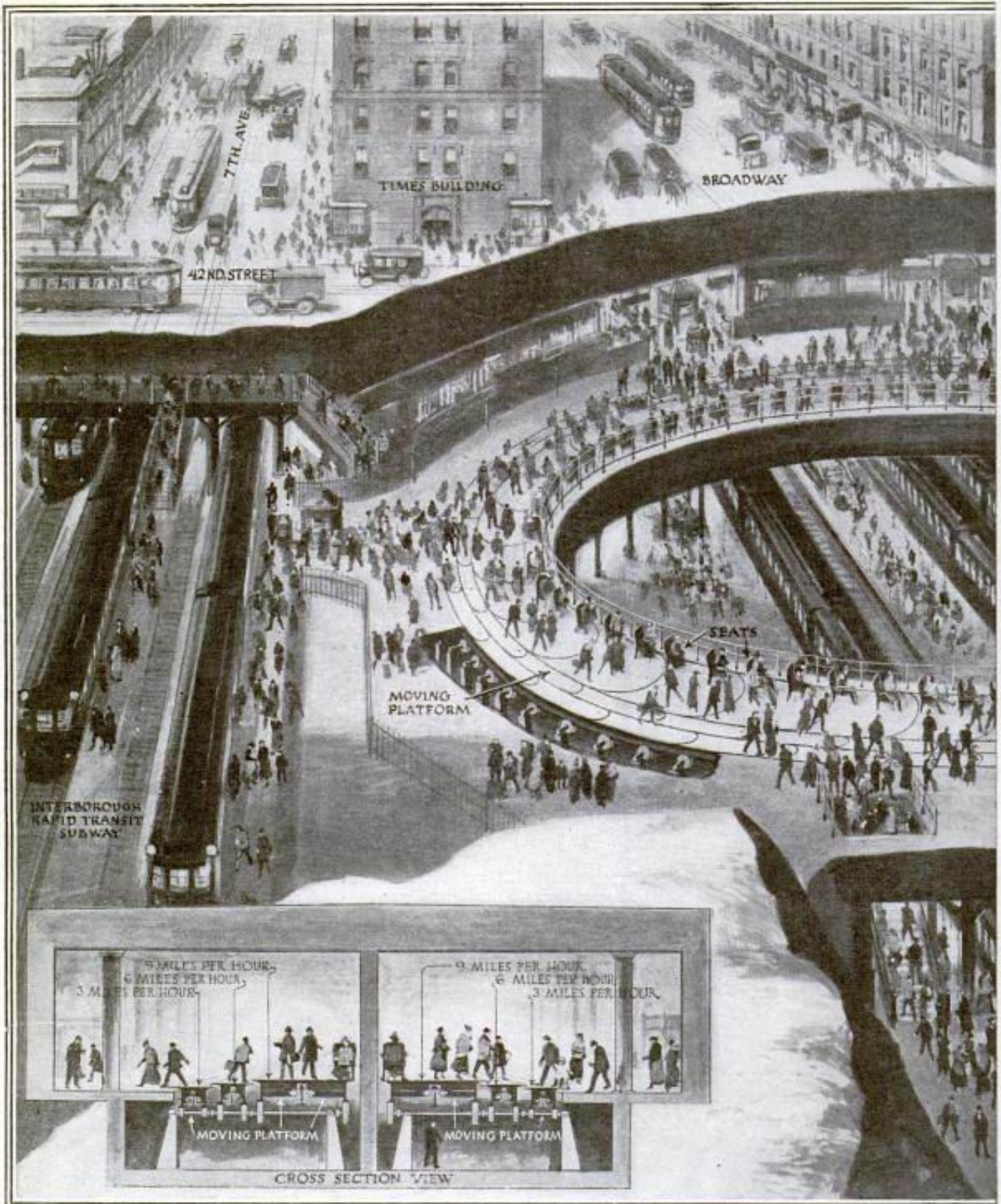




Designed for the heavy work of hauling coal over Appalachian grades, giant "Jawn Henry" is big and black and powerful, dwarfing sleek No. 600, a bullet-nosed, streamlined passenger locomotive. The Norfolk and Western is the only major railroad in the United States that has stuck to steam for all freight and passenger operations. With the great part of its revenue coming from haulage of coal, the road uses coal-fired steam for motive power. No. 2300 is the latest N&W effort to prove the diesel experts wrong



And the Transportation Engineer Said:



NEW YORK has street cars, subways, and elevated trains, and still its millions of people find it hard to travel from one part of the city to another without fighting for a place to stand up in, much less to sit down. Sooner or later New York must come to moving sidewalks. It is an old idea, revived, with improvements of his own, by Hjalmar E. Skouger, a construction engineer.

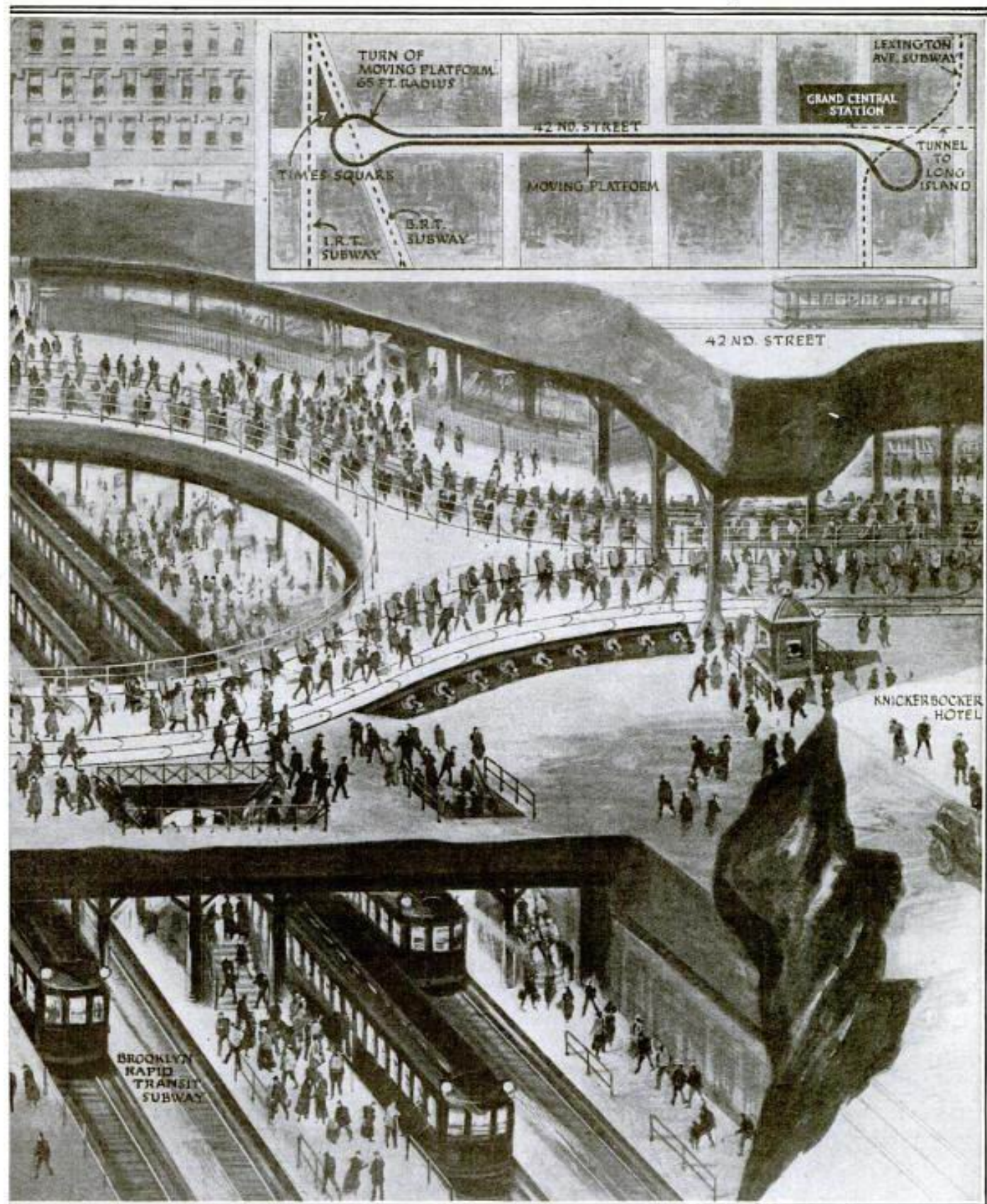
Similar apparatus is now used in carrying half finished products from one department to another in factories, or in loading or unloading steamships and railroad cars. The moving platform for transferring human cargoes consists of short units of steel or wood, formed in an endless chain, and actuated by gearing beneath it. It may consist of three or four par-

allel sections, the first going at the rate of three miles an hour, the second at six, and a third at a speed of nine miles, or even a fourth proceeding at a still higher rate. Passengers step from a stationary platform to the first section, and go by scarcely perceptible stages to the fastest strip. When they wish to alight they return to the three-mile gait, which is about that of an ordinary walk. The platforms may or may not have seats for the public, as traffic conditions require.

Exits to the street above can be arranged at short intervals; for an underground line could be skirted by an arcade that would be a continuous station.

The distance to be covered in Forty-second street, New York city, 3,000 feet, would require approximately 6,000 feet of

"Let the Sidewalks Move"—And They Moved



moving platform. The main difficulty in installation would be in making turns at the terminals. Mr. Everhart Smith, inventor of the best known type of platform, says that this can be done in a circle with a radius of sixty-five feet, without encroaching on building lines any more than at present. His estimate is that the device can be kept in motion, even with many passengers standing on it, with about 200 horsepower.

The ten-car subway express trains are driven by motors capable of developing 2,000 horsepower, but no such energy is needed because of the heavy losses of electric current due to stopping the trains and starting again. This moving platform would be a continuous, non-stop train. If the platform stalled,

the passengers could step off or walk along it to their destinations.

No conductors are needed, and one engineer does all the work. Inspectors stationed beneath the belts take the place of track-walkers. A few ticket-takers and -choppers would be required. All the engineering and operating points have been worked out for exhibition purposes with success.

At the World's Fair, held in Chicago in 1893, a local company organized by Mr. Smith operated the first moving sidewalk, 4,400 feet long, which was ridden on often by 6,000 persons at one time. A second was installed in Berlin in 1896; while at the Paris Exposition in 1900 a third one, four and one half miles in length, was patronized daily for months by throngs of sightseers.

Army Troop-Cargo Carrier Rolls on Rubber Pillows



Eight giant air pillows take the place of tires on the experimental "Teracruz," a cargo and personnel carrier built for Army Ordnance. The tire bags, inflated to a pressure of three to five pounds, swallow up surface irregularities to give the springless 20-ton vehicle a safe and comfortable ride over all types of terrain. The four trucks on which the carrier rests can be tilted forward or backward 10 degrees so that half of the bags act as compactors in

snow and soft terrain. Air pressure in any or all of the bags can be changed by the driver while the carrier is in motion. The Teracruz is propelled at speeds up to 25 miles per hour by rubber-coated steel rollers resting on top of the bags. The machined rollers mesh with the tread of the bags to turn the pillow wheels. A driver and an observer-navigator man the vehicle, which is powered by an air-cooled, 8-cylinder, 340-horsepower engine.

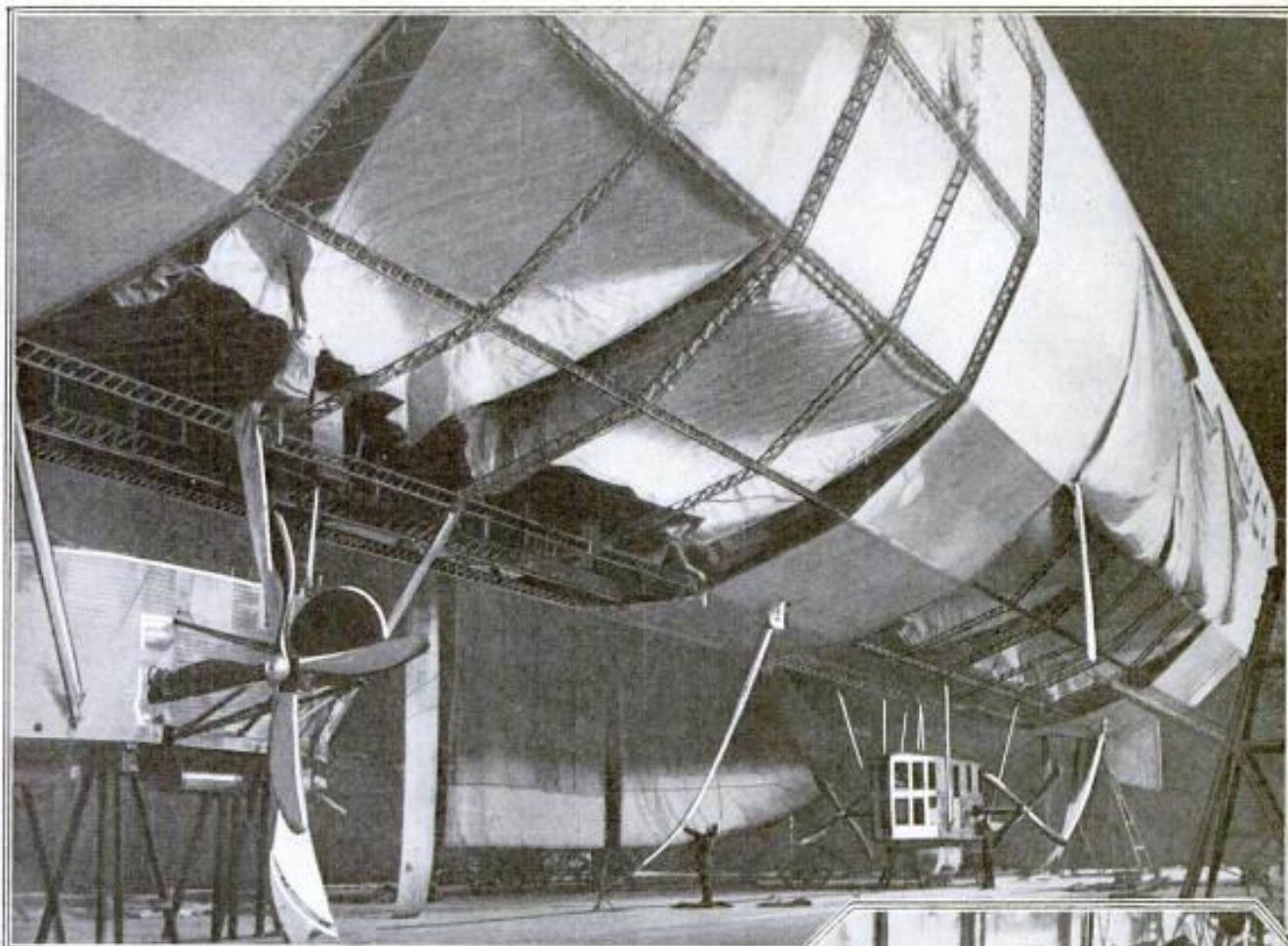


Net Clamped to Side of Boat Holds Fish and Two Rods

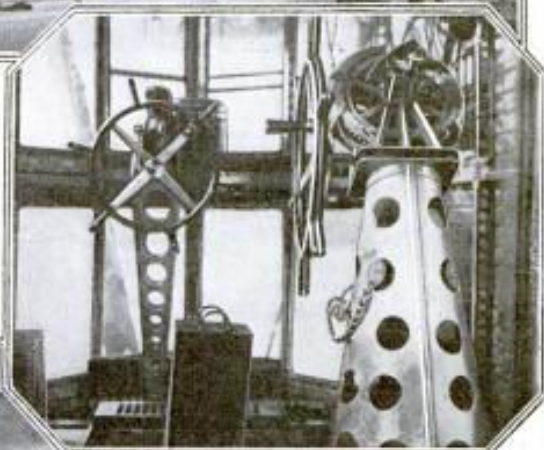
Performing double duty, a new net not only holds the angler's catch but also supports two fishing rods. The net is clamped to the side of the boat with one of its two 12-inch supporting rings under water. The angler drops his catch into the net to keep the fish alive. He also can slip the two fishing rods through steel rings, which hold the rods in fishing position.

"Perfect" Iron Crystals Produced in Laboratory

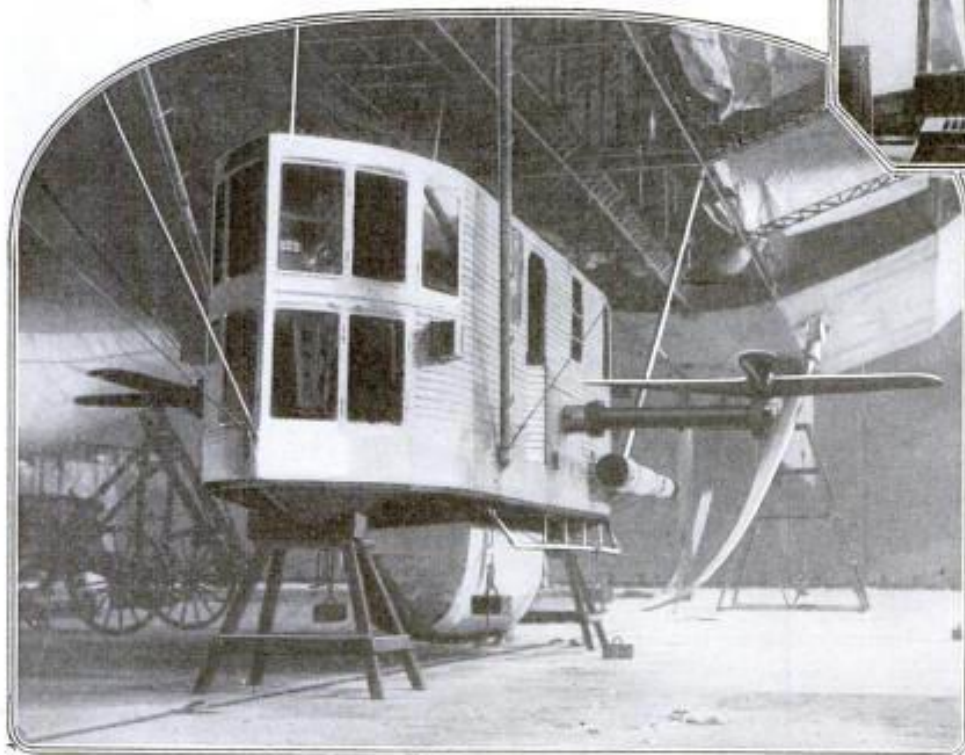
Slivers of iron so pure they can be considered "perfect" have been produced in the laboratory. Scientists at Westinghouse Research Laboratories have made the pure iron in crystals up to two inches long and $\frac{1}{1000}$ inch thick. Tests show that the crystals have a breaking strength of almost 1,000,000 pounds per square inch—10 times the strength of ordinary iron which has been drawn into wire.



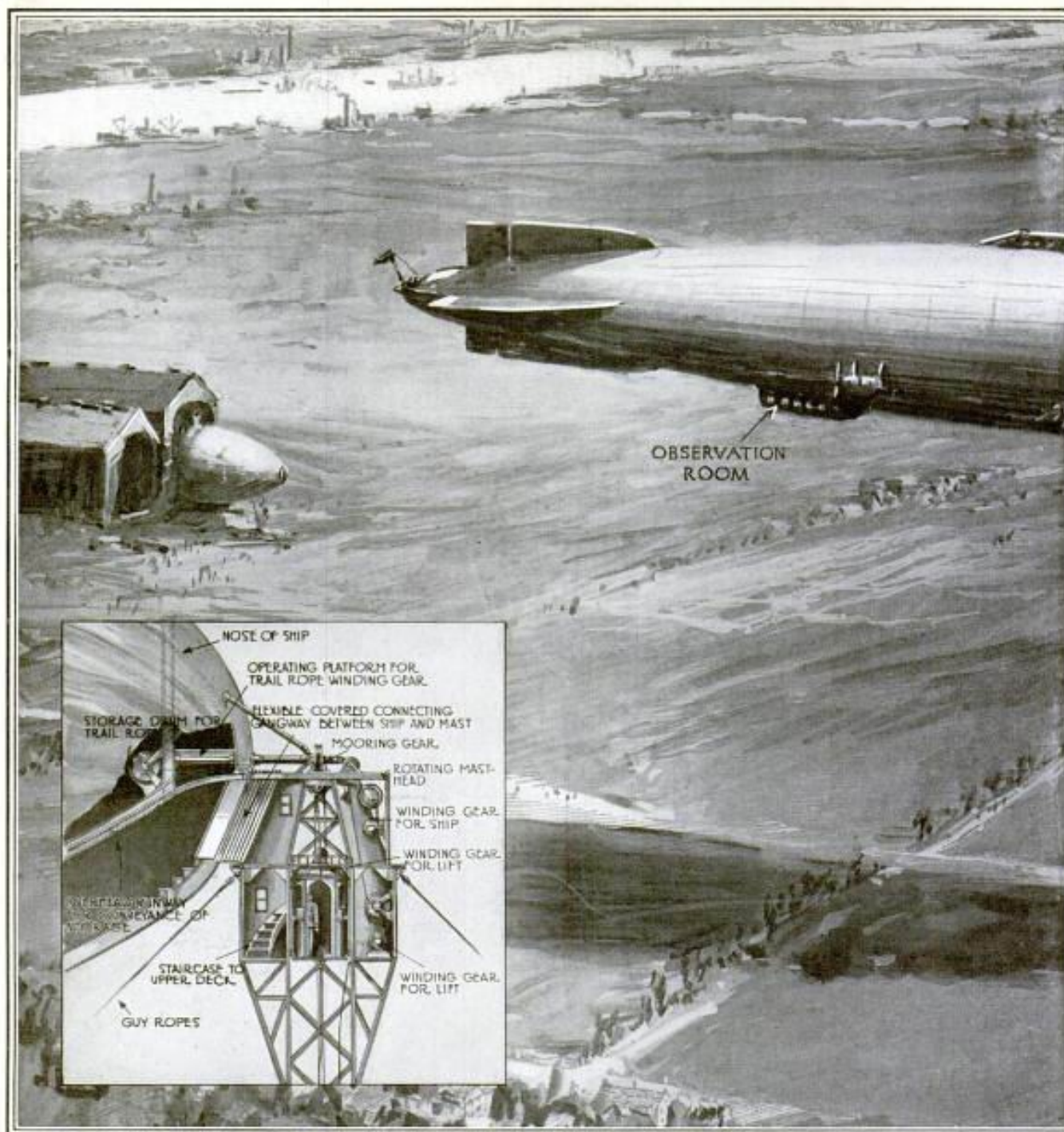
Here she is in her shed—a giant British Zeppelin. Will the rigid dirigible of the future be thus housed whenever she finishes a voyage? We doubt it. It is very likely that in the future sheds will be used only for purposes of overhauling and repairing. This ship is the R-33, the largest of British Zeppelins, which has fuel capacity and engine power enough to cross the Atlantic



Just like the bridge of an ocean steamer, you say. And you are right. All the navigating instruments and appliances of the *Mauretania* are found on board a Zeppelin, with a few more (such as height indicators) that the captain of the *Mauretania* never needs



The engines are inclosed in separate cars, as this picture shows. When helium instead of highly explosive hydrogen is used to inflate the bags in the envelope above, it will be possible to put the engines right in the hull and thus give the craft cleaner lines



London to New York by Air: Across the Atlantic

[Mr. Dienstbach wrote the preceding article for POPULAR SCIENCE MONTHLY before we received the following contribution from our British correspondent. Since the project of Messrs. Vickers is soon to be realized, we thought it well to present their construction of a Zeppelin mooring-tower side by side with Mr. Dienstbach's. As a matter of fact, Mr. Dienstbach proposed the mooring-tower fully fifteen years ago, when Zeppelin after Zeppelin was wrecked on the ground in high winds.—Editor.]

GREAT BRITAIN has been making plans to institute a regular transatlantic airship passenger service between London and New York. Soon you will book your pas-

sage to London by air-liner and cut your time of crossing in half. Seasickness will be a thing unknown. You have ocean-liner comforts. When you are hungry you will walk into a well supplied restaurant. Luxurious berths invite you at bedtime.

The designers of these giant dirigibles are Messrs. Vickers, Ltd., the well known British armament-makers.

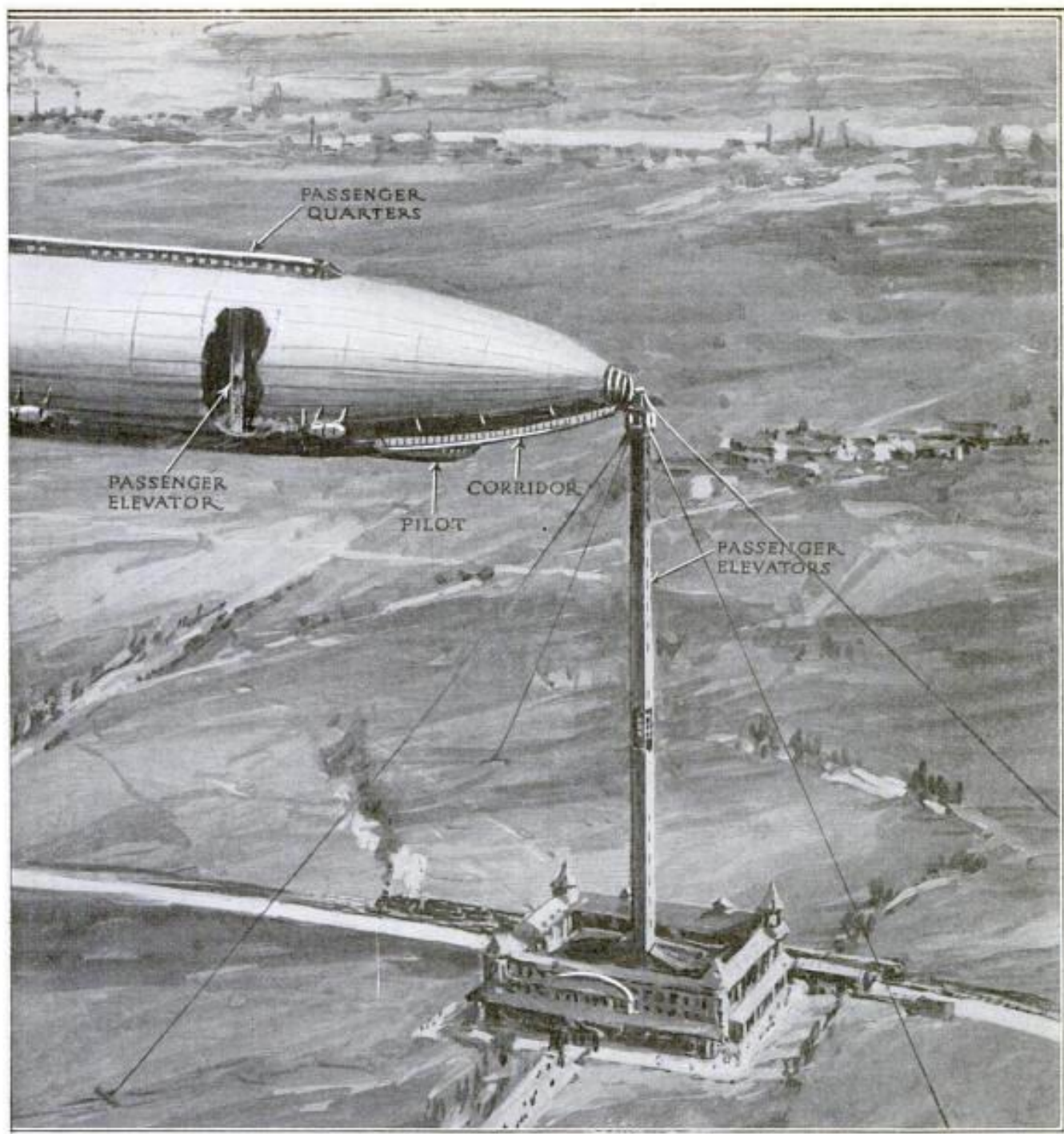
The air-liner proposed will have a length of eight hundred feet and a diameter of one hundred feet. It will surpass any German Zeppelin in size as well as in speed. The hull outline will be a perfect continuous streamline

By C. A. Oldroyd, Correspondent of the

shape, with no external projections save the six cars carrying the propelling machinery and the stabilizing and steering planes near the tail of the ship. It will carry one hundred passengers and a crew of nineteen.

The passenger accommodation will be on top of the airship, for here no vibration due to the engines will be felt. The crew will be accommodated in the keel of the ship.

This internal keel runs the whole length of the ship, and an elevator connects the keel with the passengers'



in Two Days in an 800-Foot British Zeppelin

Popular Science Monthly in Great Britain

quarters. A shelter-deck, fire-proof smoking-room, and observation saloon will be provided.

Six engines, giving a total propelling horsepower of 3,500, are provided in the six cars to drive the ship at a speed of seventy-five miles an hour.

But building the airship alone is only half the problem. A shed capable of housing two giant airships costs about two million dollars, while the complete air-liner would cost less than the shed. Recognizing that the shed will have to be eliminated if commercial airships

are to become a fact, Messrs. Vickers set to work and perfected a mooring-gear for airships.

By this means the ship can be moored to a mooring-mast and ride out the severest gales in perfect safety. This mast allows the ship to swing in every direction while held firmly. The ship can be released instantaneously when desired. The mast is about one hundred and fifty feet high. Four strong steel cables are secured to the masthead at one end and to deep concrete foundations at the other.

The mast itself is of square cross-section, and an elevator travels inside.

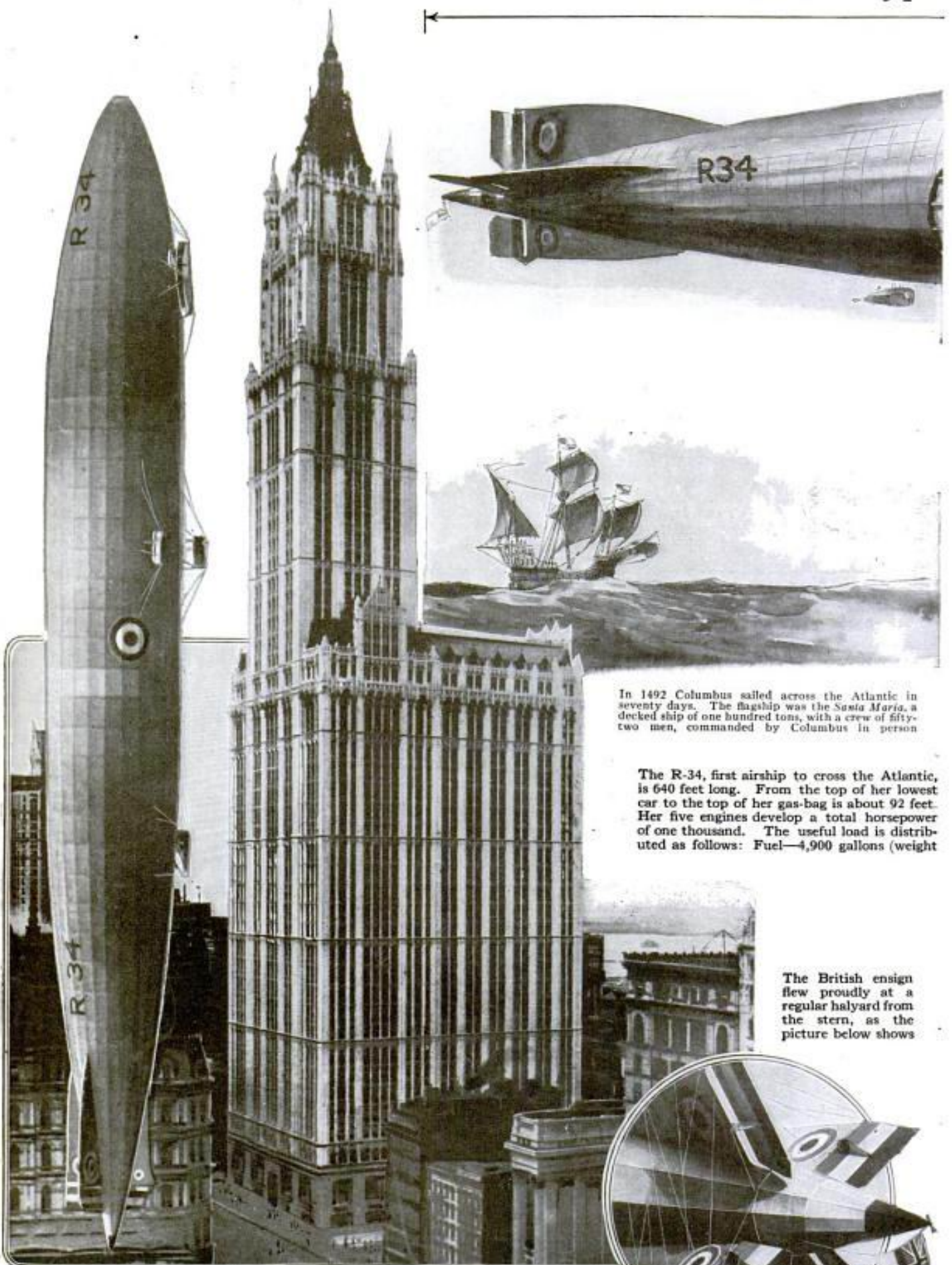
Gas, water, oil, and gasoline supply-pipes are also carried inside the mast.

When the elevator reaches the revolving top of the mooring-mast the passengers enter the ship through the bow immediately below the mooring-gear. A flexible, covered corridor, similar to the connection between Pullman cars, connects ship and mast.

A second elevator takes the passengers from the keel to the top of the ship, while a small runway conveys food, mail, and cargo to the store-rooms.

The passenger rate from London to New York is £115 (\$575), while mails cost only fifteen cents an ounce.

The First of Their Type



In 1492 Columbus sailed across the Atlantic in seventy days. The flagship was the *Santa Maria*, a decked ship of one hundred tons, with a crew of fifty-two men, commanded by Columbus in person

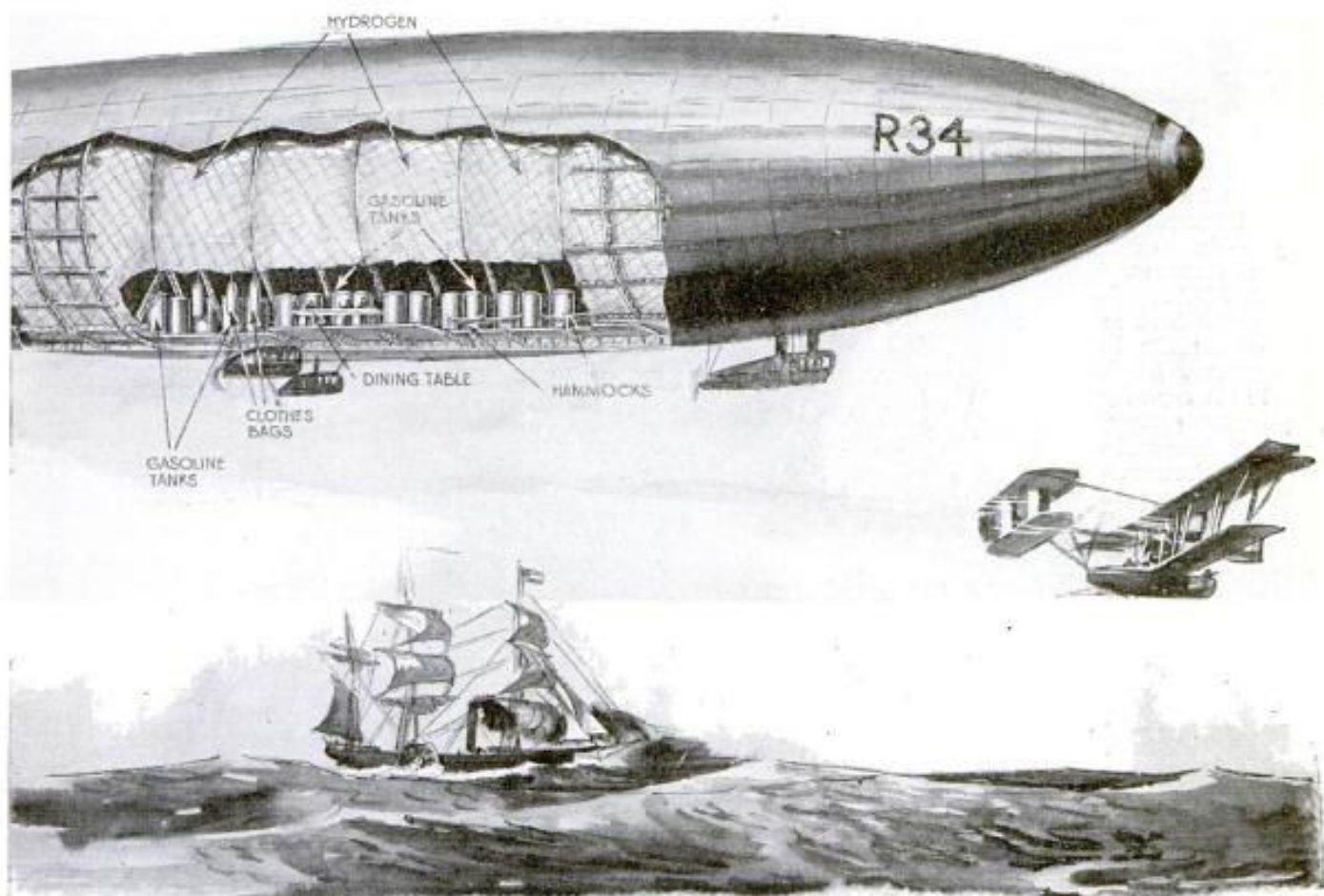
The R-34, first airship to cross the Atlantic, is 640 feet long. From the top of her lowest car to the top of her gas-bag is about 92 feet. Her five engines develop a total horsepower of one thousand. The useful load is distributed as follows: Fuel—4,900 gallons (weight

The British ensign flew proudly at a regular halyard from the stern, as the picture below shows

If the R-34 could stand on end beside the Woolworth Building, she would be topped by the building's flagstaff one hundred feet. But England has announced her intention of building an airship eleven hundred feet long

to Cross the Atlantic Ocean

631 FEET



The first steamship to cross the Atlantic, which was one hundred years ago last spring, was the *Saranwak*. She was 130 feet long; her horsepower was only 90; her speed but 6 knots. It took her thirty-seven days to cross

The NC-4 has a wing span of 126 feet, almost as great as the *Saranwak's* length. It took her about twenty-five hours to cross the Atlantic Ocean

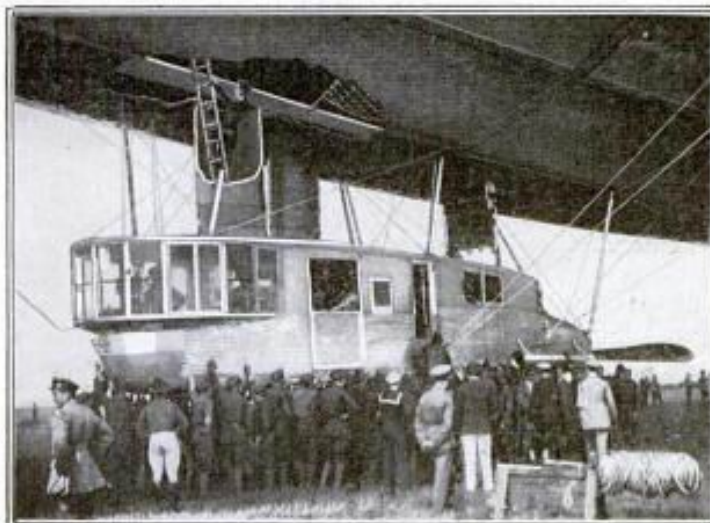
35,300 pounds or 15.8 tons); oil—2,070 pounds (.9 tons); water—3 tons; crew and baggage—4 tons; spares—550 pounds; drinking water—800 pounds. The total is 24.32 tons. The R-34 had thirty-one souls aboard. The crew included two wireless operators, who had sev-

eral sets of instruments at their disposal. The broken away section of the picture shows how comfortable the passage must have been. Good hammocks, hot food cooked on simple devices attached to the exhaust pipes of the engines—what more could be reasonably ex-

pected? The R-34 is a Zeppelin with a vengeance. The arrangement of cars, propellers, rudders, etc., is exactly like those of the large German Zeppelin L-49, which was captured in France intact and which was fully described in the *Popular Science Monthly* last year

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To reach the envelope from the forward car, you climb up an aluminum ladder through a pipelike passage. Felt shoes must be worn, lest you strike sparks from the rungs. The huge envelope contains eighteen compartments of explosive hydrogen. The vessel is as safe as a powder factory



The two cars in the middle, of which this is one, were not in danger of bumping while the ship was tethered near the ground, because they are higher than the cars at the end. These cars are all engine. Cylinders, flywheels, valve-gearing, and all else crowd the interior

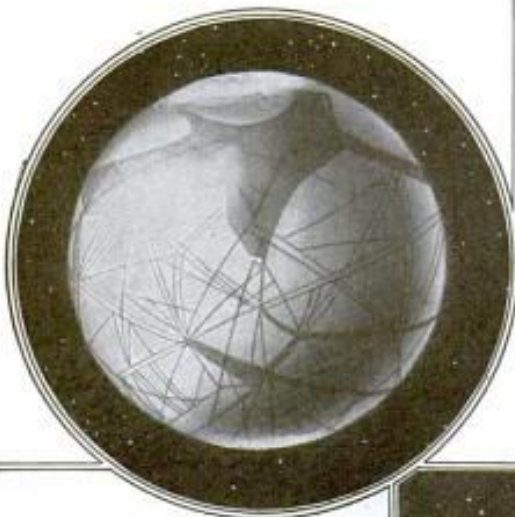
"Hello, Mars—This Is the Earth!"

THE more imaginative modern astronomers are inclined to believe, with the late Professor Percival Lowell, that Mars is inhabited. Assume that Mars is inhabited. How can we talk to the Martians? What a world-wide sensation there would be if we were to receive from Mars a flash in response to a signal of ours!

But how will the scientists signal to Mars? At its nearest, the planet will be about thirty-five million miles away in 1924. Various proposals have been made by Professor Pickering, Professor Wood, and the imaginative Professor Flammarion. In order to visualize and explain how these distinguished astronomers will communicate with Mars, Mr. Max Fleischer has directed the preparation of a motion-picture film for the Bray Studios. Through the courtesy of Mr. Fleischer and the Bray Studios we are enabled to present on these two pages excerpts from the film

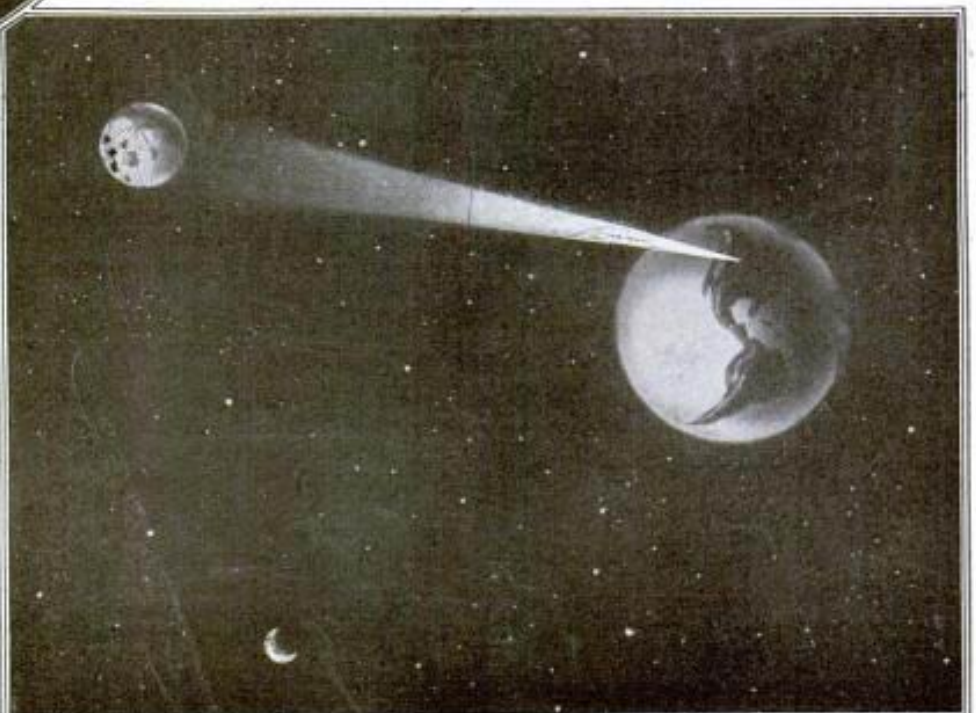


The well known French astronomer, Professor Camille Flammarion, to popularize the notion of Mars' habitability, suggested that an electric light. It would be a costly experiment. A huge tract of Sahara, for instance—would have to be "planted" with the lamps would have to be generated in a power house big once said that he hated to die rich. Here is a chance to



The distinguishing features of Mars are its "canals," first discovered by Schiaparelli and later minutely studied by Lowell. It was Lowell who advanced the theory that the canals are great irrigation ditches. Mars has almost dried up. Water is to be found only at the poles. If vegetation is to flourish, the water of the melting polar snows must be conducted to the arid regions. Hence the canals. Several hundred were charted by Lowell. The canals are the only evidences of intelligent life that we have

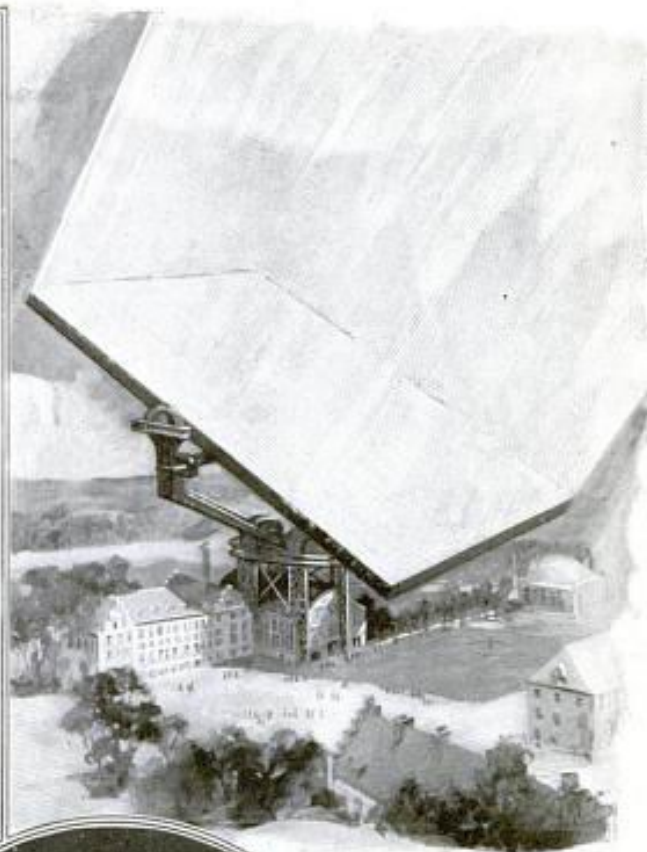
To the right we have the earth flashing a message to Mars. Who knows but some day we may tell the Martians all about our great war, all about the struggle for democratic ideals, all about the terrible upheaval through which we have just passed! Perhaps we will learn from an older and wiser planet how we ought to run the Earth



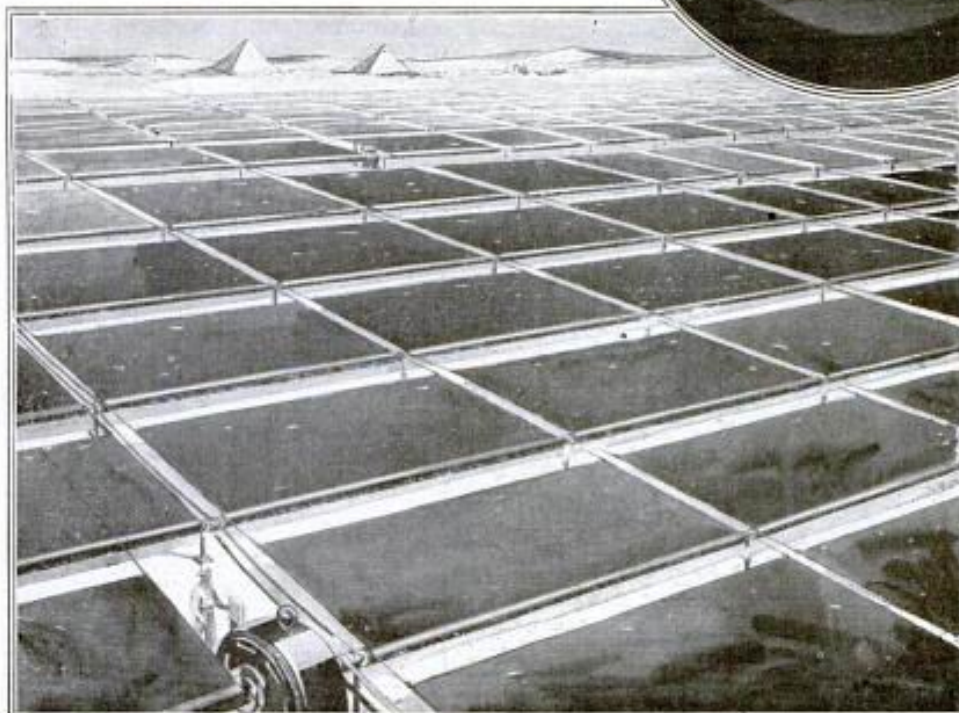
Will the Martians Answer Us?



who has done more than any other man in Europe enormous area on the Earth should be covered with of land—a considerable portion of the Desert millions of lamps. The current to illuminate enough to run a railway. Andrew Carnegie get rid of several million dollars at one swoop



Professor Pickering, of the Harvard College Observatory, suggested that a huge mirror be mounted, to swing on an axis so that it can reflect the sun's rays to Mars from any angle. It would take an enormous power plant to flash dots and dashes to the wondering Martians. And what would they see? As the picture on the left shows, a luminous spot which alternately glows and extinguishes itself



The picture at the left is like a neatly cut-up farm. It represents Professor R. W. Wood's proposed method of communicating with Mars. The Professor would cover some huge white space on the earth, a portion of the Desert of Sahara, for instance, with strips of black cloth. These strips he would wind and unwind by means of electric motors. The result would be a series of winks. When the black strips are wound up, the white sand below reflects the sun's rays; when the strips are unrolled, the white area is covered. This is probably the cheapest method of optical signaling yet proposed

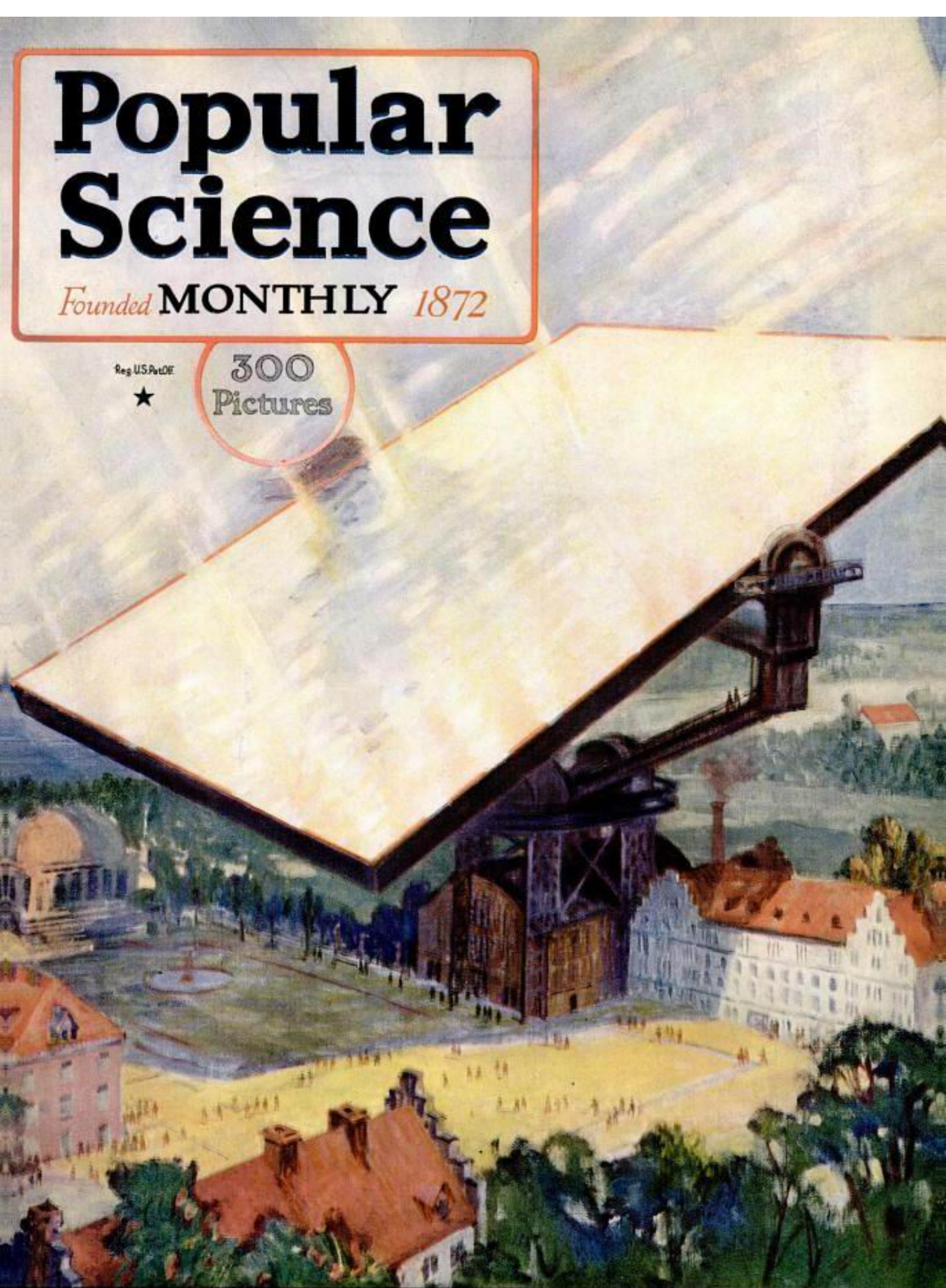
Popular Science

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300
Pictures





There is not a roof on Manhattan Island large enough for airplanes to land on. The passenger-carrying airplanes of the near future will require an open space of at least a mile square. Dr. Thomson's plan for New York city is the reclaiming of about four square miles of land between the Battery and Staten Island, and the construction thereon of huge terminal buildings to accommodate steamships, motor-trucks, and airplanes. He estimates the cost of this new city at \$100,000,000.

Redrawn from a picture © by Success Postal Card Co.



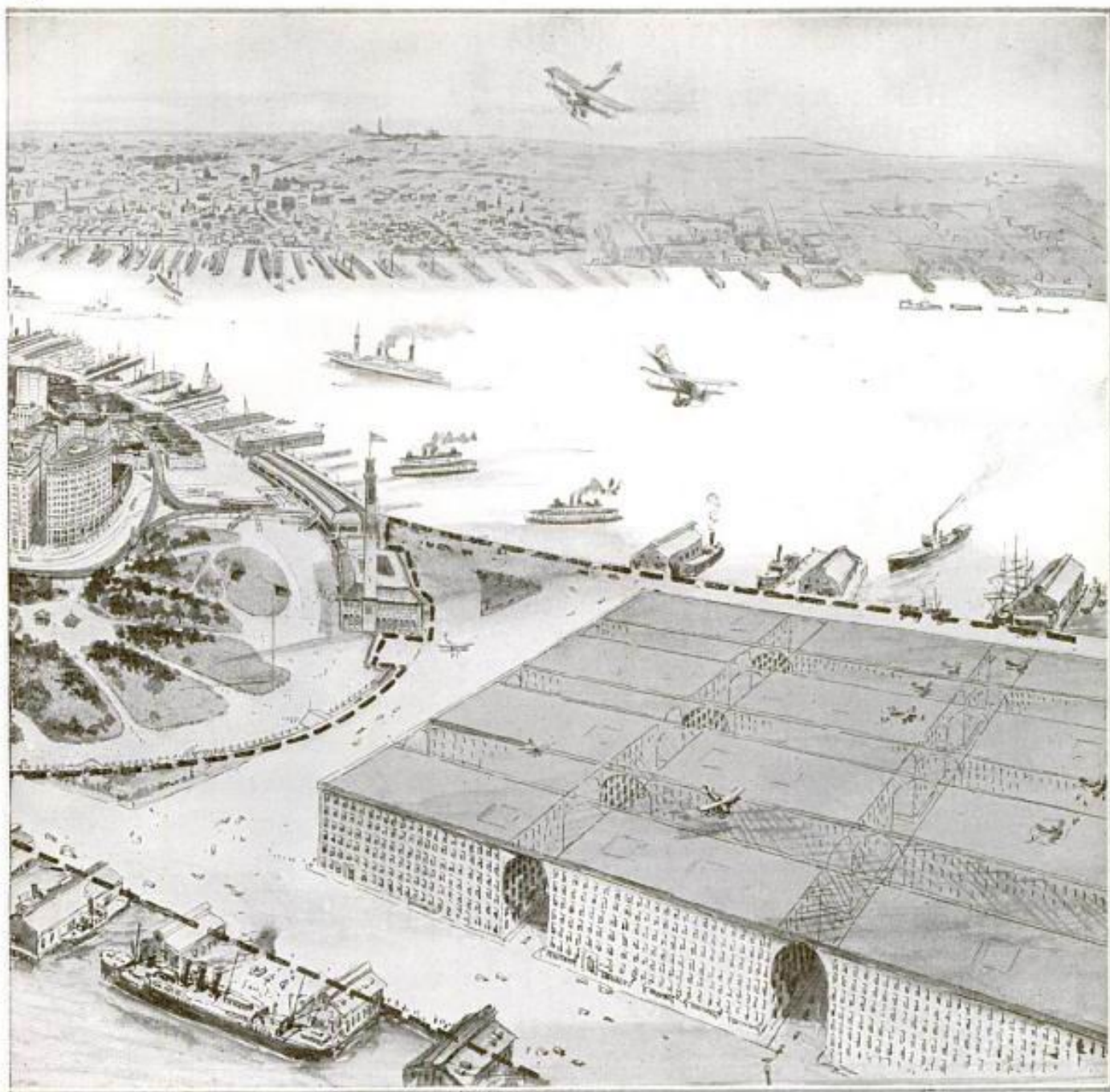
A Plan to Extend New York

By Dr. T. Kennard Thomson,

[Dr. T. Kennard Thomson, whose daring plan for making New York a great port for airplanes is published here, is an acknowledged authority on pneumatic caissons. He has been retained as consulting engineer in the construction of many New York skyscrapers, and has built pneumatic caissons for important bridges over many of the larger rivers. He was one of the board of five engineers in charge of the construction of the New York Barge Canal.—THE EDITOR.]

THE problem of the automobile is roads; that of the airplane, landing-places. And, just as good roads have followed the invention of the automobile and the automobile has multiplied with good roads in a never-ending succession, so airplanes in commercial use will multiply with properly laid out chains of landing-places and the landing-places will multiply with the demand of the airplane.

At present the location of landing-places is controlled by circumstances. Mineola, set in the plains of Long Island, becomes the airplane port of New York. But it is as if ships coming to New York had to dock at Sandy



to Make a Great Airplane Port

Consulting Construction Engineer

Hook and leave their passengers to make their way to the city as best they could. It frequently takes the passenger or the mail package coming by airplane from Washington to New York longer to reach Manhattan after landing on Long Island than it did to fly from the capital to the landing-place.

Wanted, then—a good landing-place in Manhattan. That means a smooth surface about a mile square. For at present the most favored types of airplanes have to run for about a thousand feet along the ground before taking the air, and, having to land at one half their maximum speed, they need space in which to settle down to earth again.

There is, of course, no such space to be had at present on Manhattan Island. Central Park is sacred as the city's one big breathing-space, and anyway it is not suited to the purpose. The answer, then, is—build such a place. My plan is this:

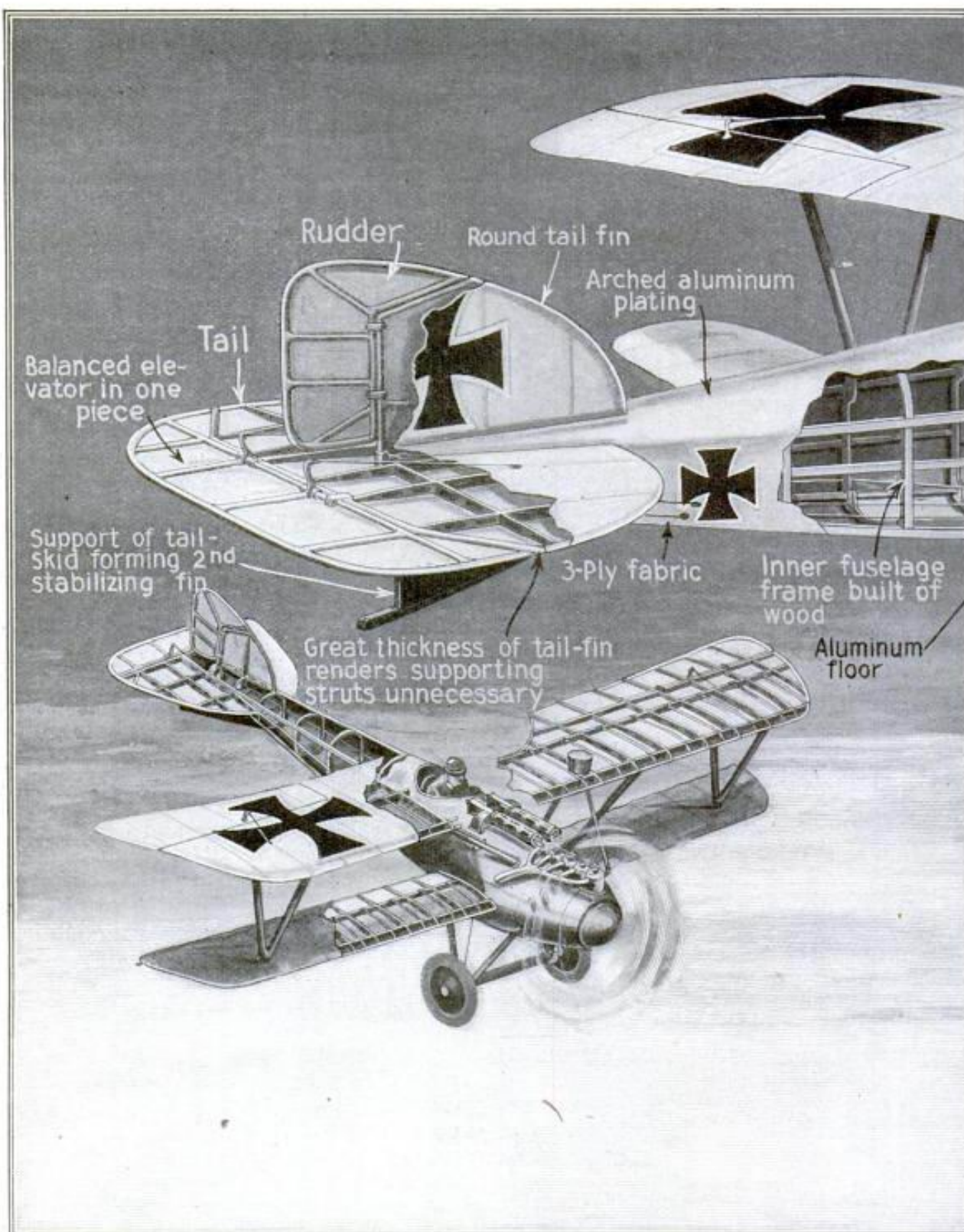
Build a great station for airplanes, steamships, barges, and motor-trucks by extending Manhattan Island at the Battery. It can be done for \$100,000,000, and the land thus reclaimed would be worth many times that amount, for it would create a new city of some four square miles.

My idea for a Manhattan extension is to construct a sea-wall from the Battery toward Staten Island in such

a way that the new Battery will be about the same distance from Staten Island as the present Battery is from Jersey City, and to reclaim the space between these sea-walls—more than four square miles.

Wherever rock is near the surface the space between the sea-walls, or cofferdams, will be pumped out; but where the rock is more than sixty or seventy feet from the surface, the space will be filled with sand pumped in through a suction-dredge having a capacity of 50,000 cubic yards per day.

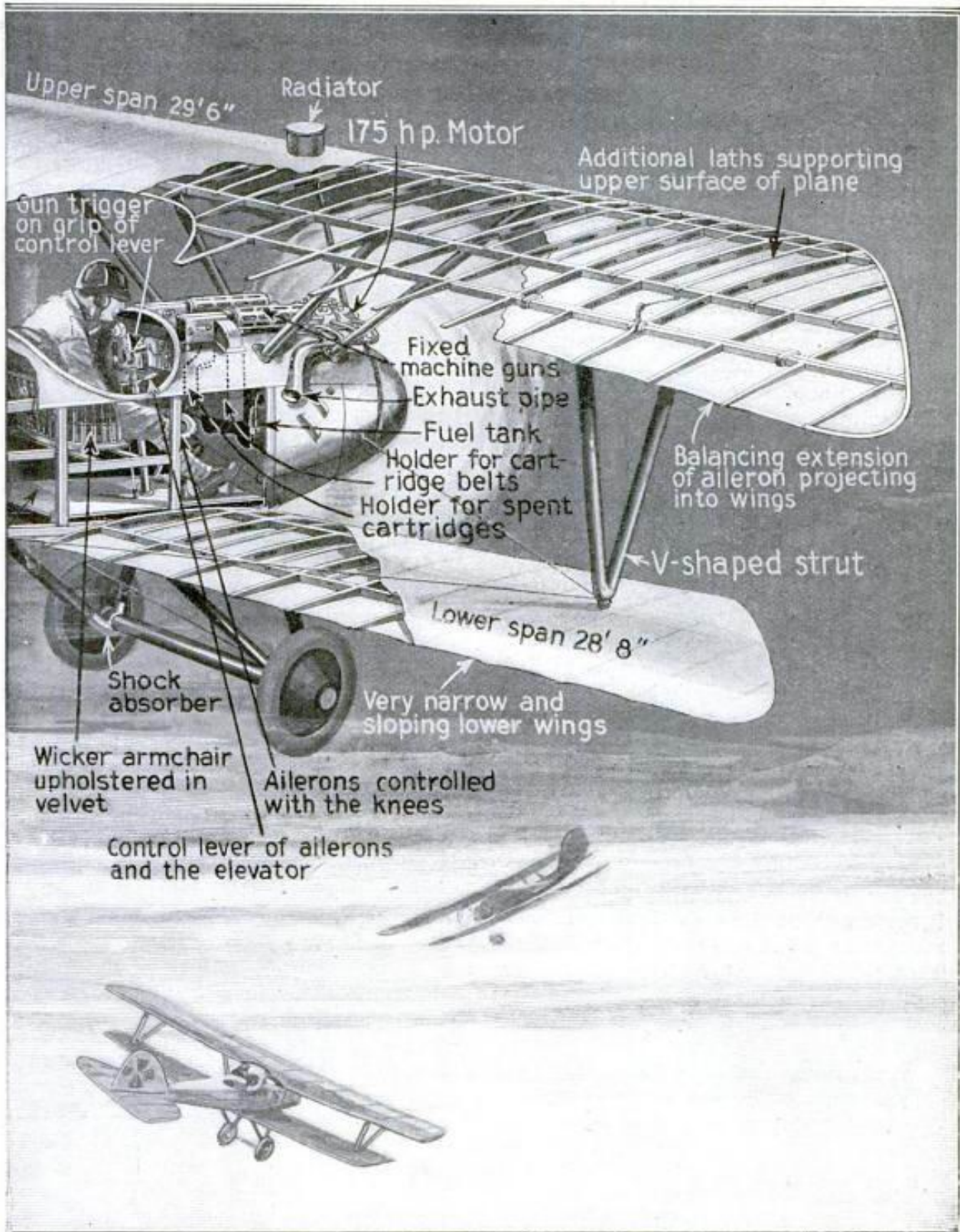
Eventually adequate landing-places will be built on top of the buildings of the new city. The buildings will cover entire blocks, and will be narrow enough to make air-wells unnecessary. These blocks can be any length—1,000 feet, one mile, four miles. There will be arcades at the street level, say every hundred feet.



In their new Albatross destroyer, which is probably the fastest fighting machine on the machines and have added improvements of their own. A stationary engine of 175 horse-

Why is the lower wing narrower than the upper? There is a kind of interference between upper and lower wings. The air is "caught," as it were, between the superposed surfaces. If the lower wing is

narrowed this interference is largely prevented. But there are structural reasons, too, for narrowing the width of the lower plane. Note in the drawing that the struts are triangular in form and that the

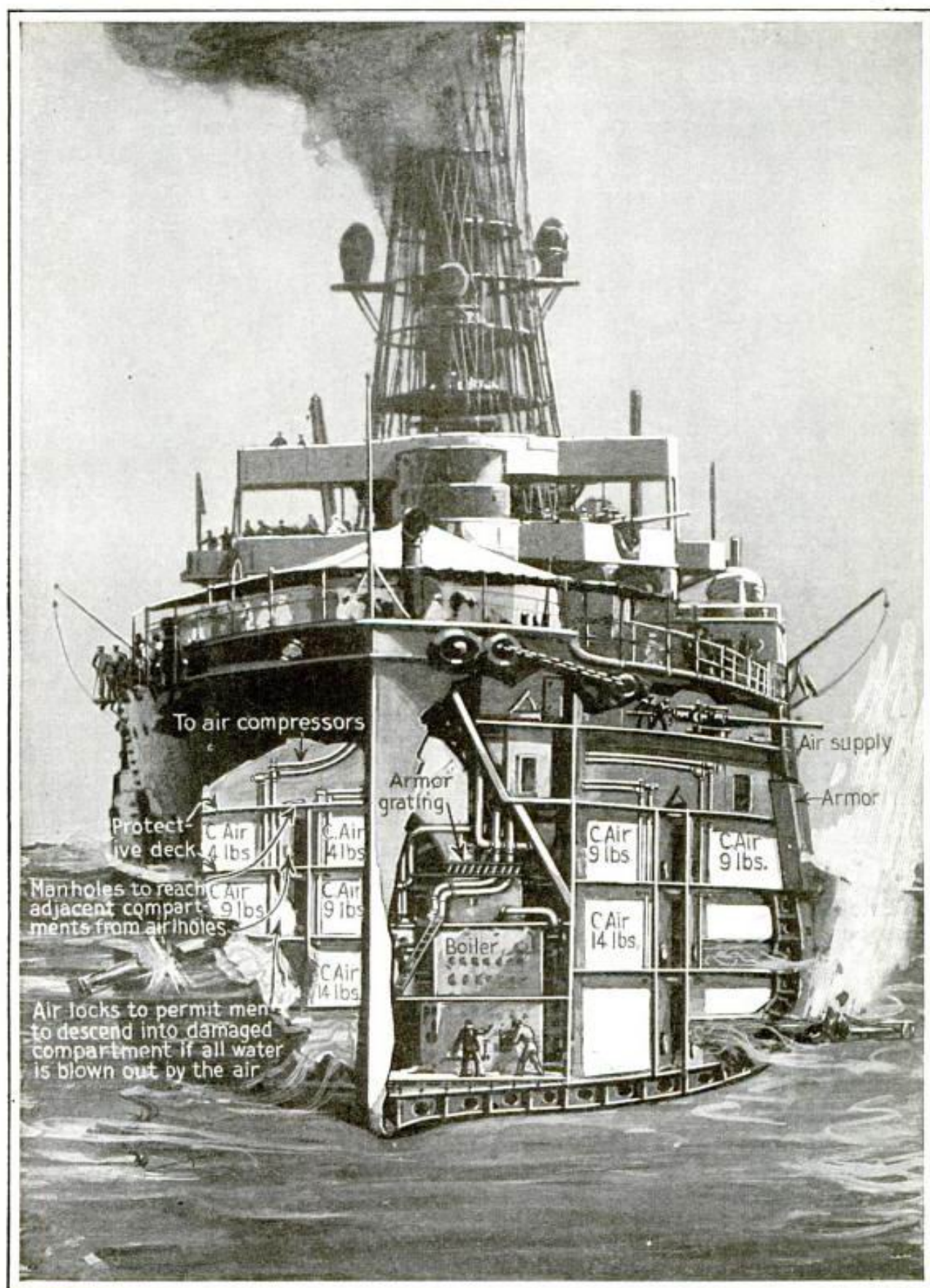


western front, the Germans have copied the best features of the French and British fighting power drives the Albatross through the air at the tremendous speed of over 130 miles an hour

rear member of a triangle lies directly behind the front member. Isn't it obvious that the triangular strut thus formed is strong and light and that it will offer less resistance to the wind than if a rectangle

with diagonal wire bracing were adopted? Note, too, that the staggered wing construction with the narrow lower plane makes it possible to fasten each triangular strut directly to the lower main beam.

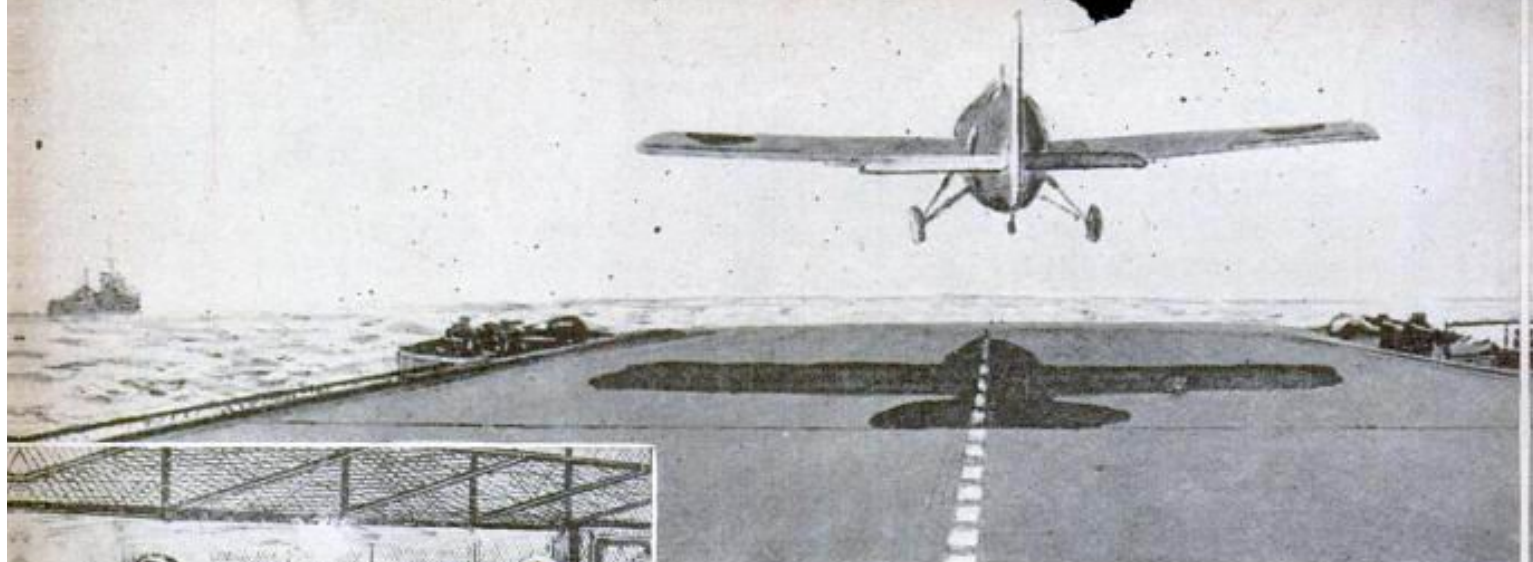
The Air-Lock Principle Applied to the Battleship



Foiling the Torpedo with an Armor of Air

The broken-away section at the left shows how the compartments in the way of the boiler-room would be filled with compressed air were the vessel hit amidships. Similarly, the section at the right shows how the compartments would be filled if the boat were hit near the bow. At the left it is noticed that the intact compartment nearest the damaged area is filled with

compressed air at a pressure of fourteen pounds to the square inch. Adjacent compartments are filled with air at the lesser pressures of nine and four pounds, according to the distance from the punctured section. A ship thus injured could proceed to port under its own steam. The air locks permit men to descend into the injured compartment to make temporary repairs.



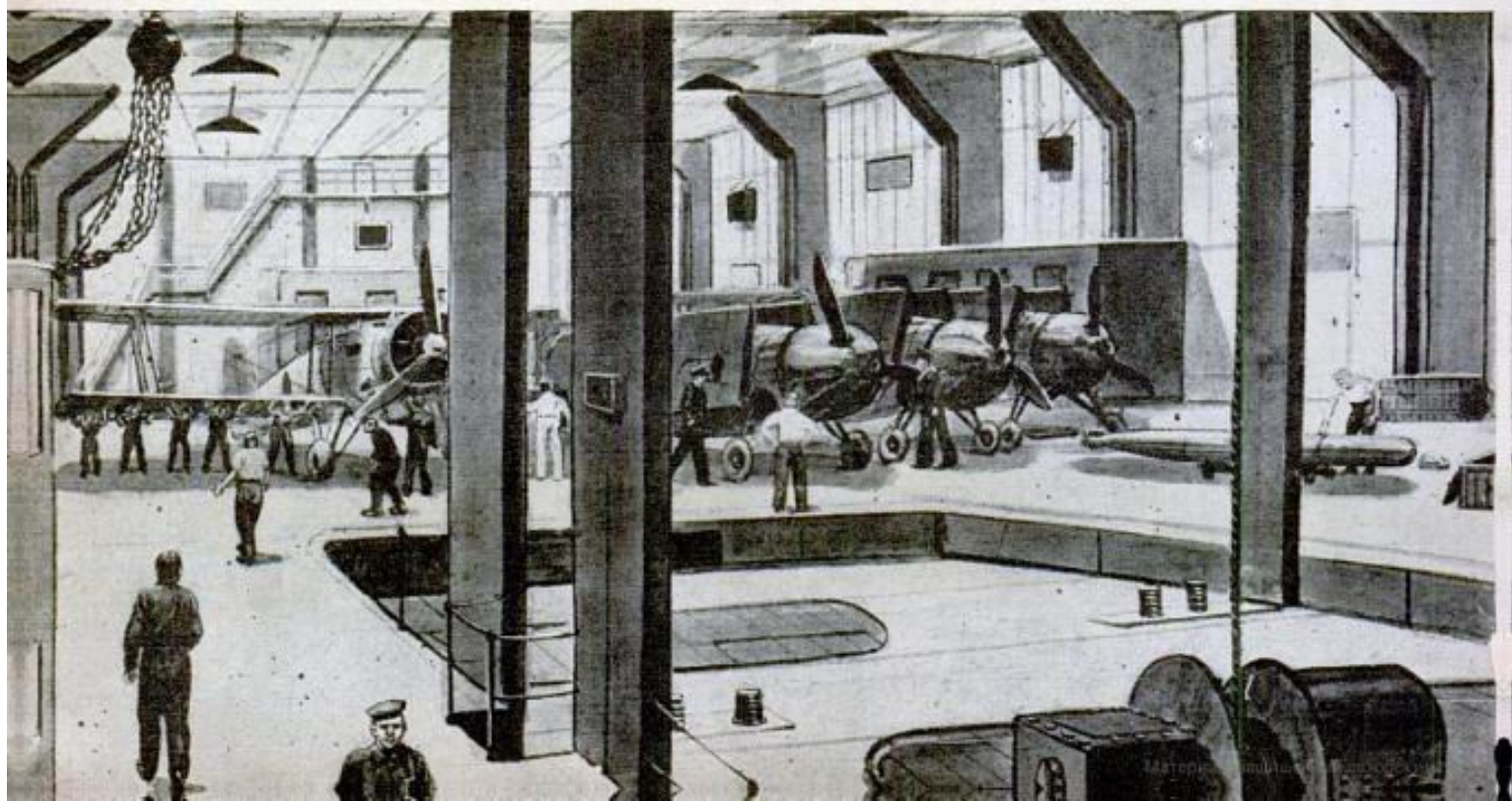
KNOCKING OUT

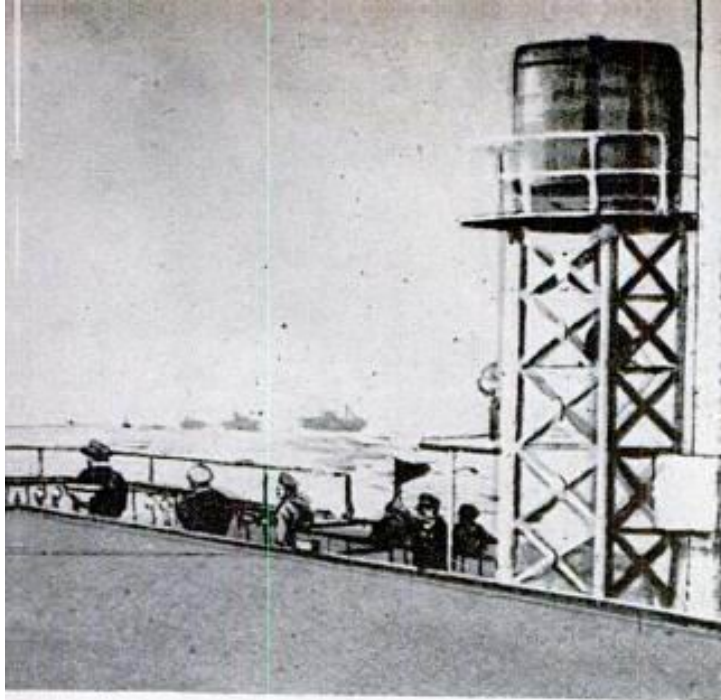
BABY FLAT-TOPS PACK PUNCH

Planes based on tiny carriers spot and kill U-boats before they even see our convoys. One of these flat-tops, converted by U. S. shipyards from cargo vessels and called "Woolworth carriers" by the British, is pictured here by G. M. Davis, artist for the Illustrated London News.

Sealtime aboard the converted carriers is welcomed by British as well as U. S. crews. The British like the cafeteria arrangement, calling it typically American. A crew's quarters are roomy, for a fighting vessel

This is one of the first views of the hangar of an escort carrier. The elevator mechanism is shown in the right foreground, while the elevator is raised. Wings are being extended on the plane at the left



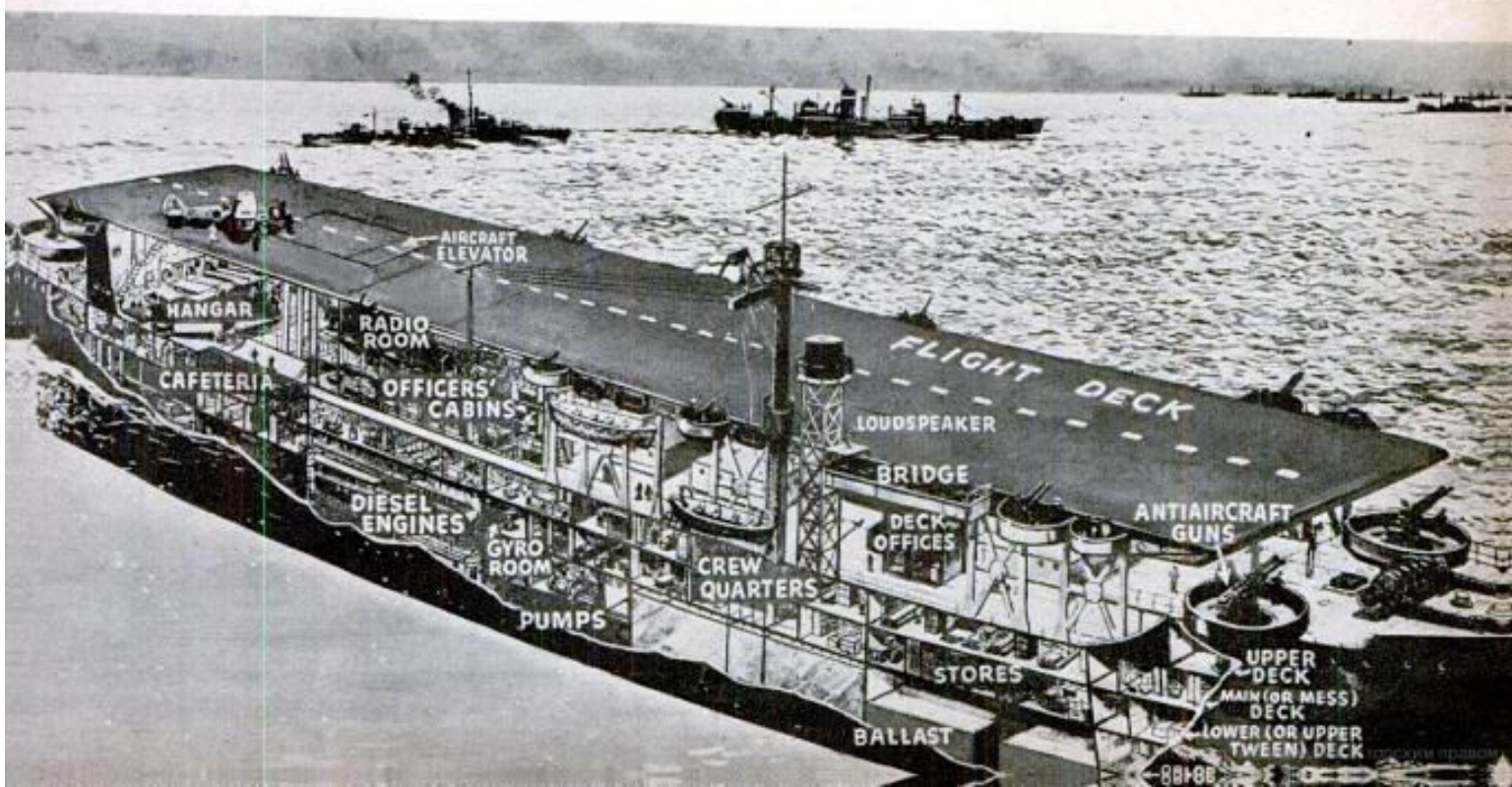
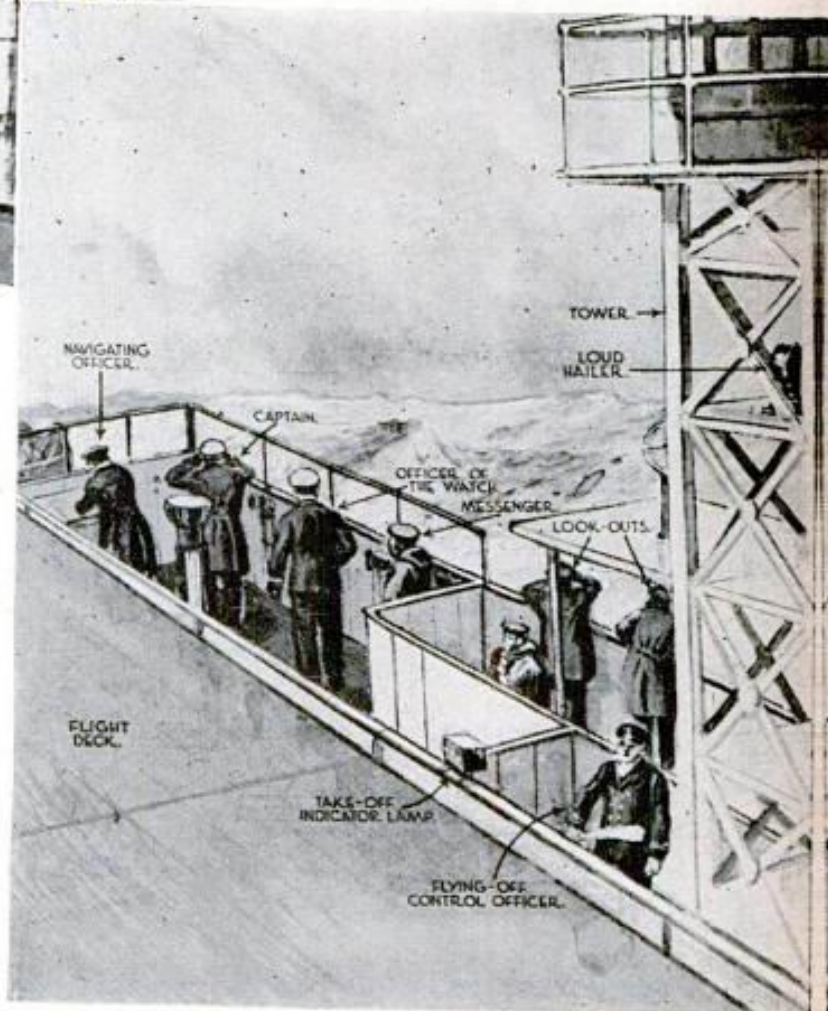


Rising from the deck of a baby flat-top, the plane at left takes part in the daily hunt for wolf-pack submarines. Aircraft from such vest-pocket carriers as this, converted in U. S. yards from 17,000-ton motorships and used by both the British and Americans, are keeping the Atlantic seaway open for valuable war shipments

THE U-BOAT

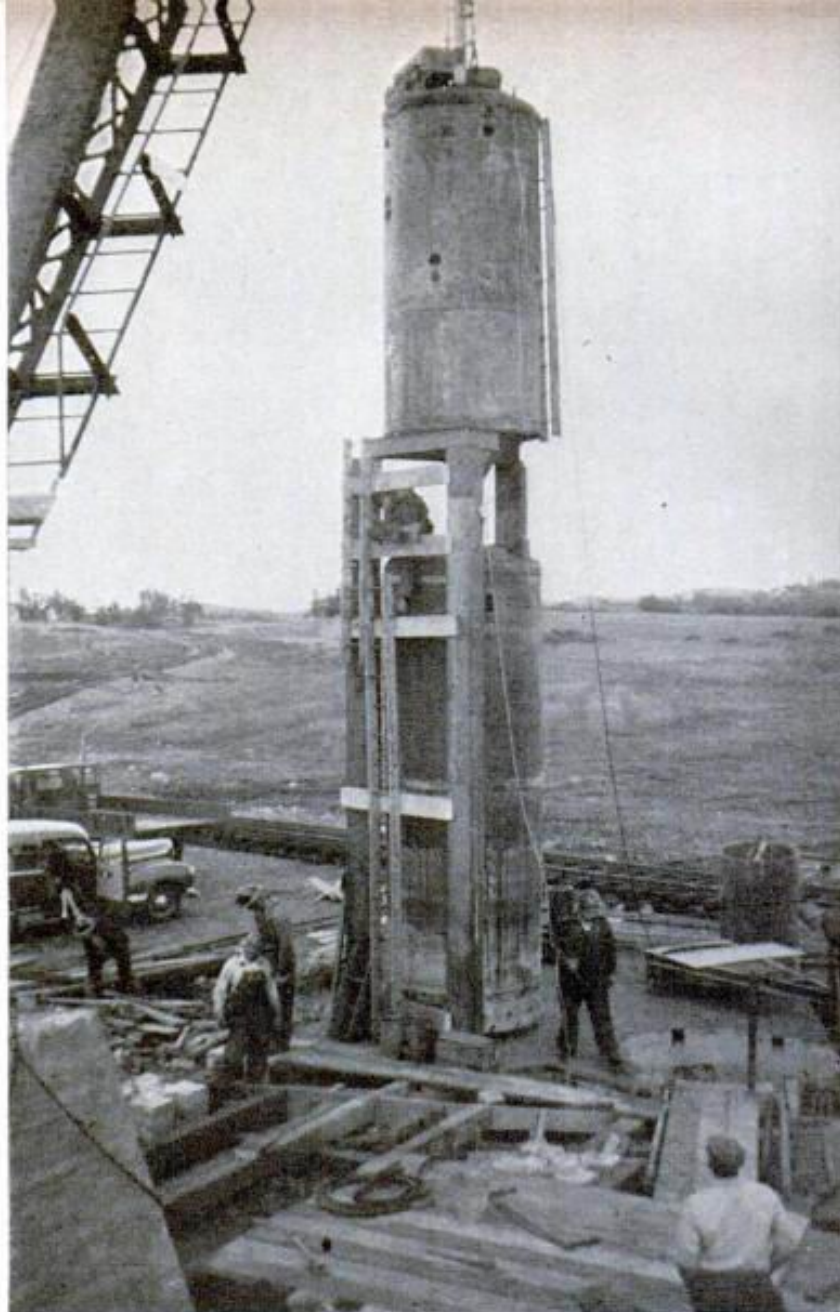
All flying as well as navigation orders come from the bridge, situated outboard on the starboard side. The officer at the extreme right is in control of the take-offs and landings. Sometimes these are very tricky in a badly pitching sea

Funnels, unnecessary in the operation of a motorship, are removed so the flight deck can stretch across the entire top to provide a maximum runway. The location of the plane elevator, shown flush with the deck, and other parts of these baby flat-tops, is given in the drawing below





Above, a 30-ton core of solid rock cut at the Zenith iron mine, at Ely, Minn. At the right, the rock corer, shown resting on a wooden stand, has been lifted out of the hole it has just drilled to allow the core puller to be sent down. Before it can be pulled, a core must be either wedged or dynamited loose from its base



He Bores Bigger Holes

HOW A CALIFORNIA ENGINEER SOLVED A PROBLEM
AND REVOLUTIONIZED METHODS OF DEEP MINING

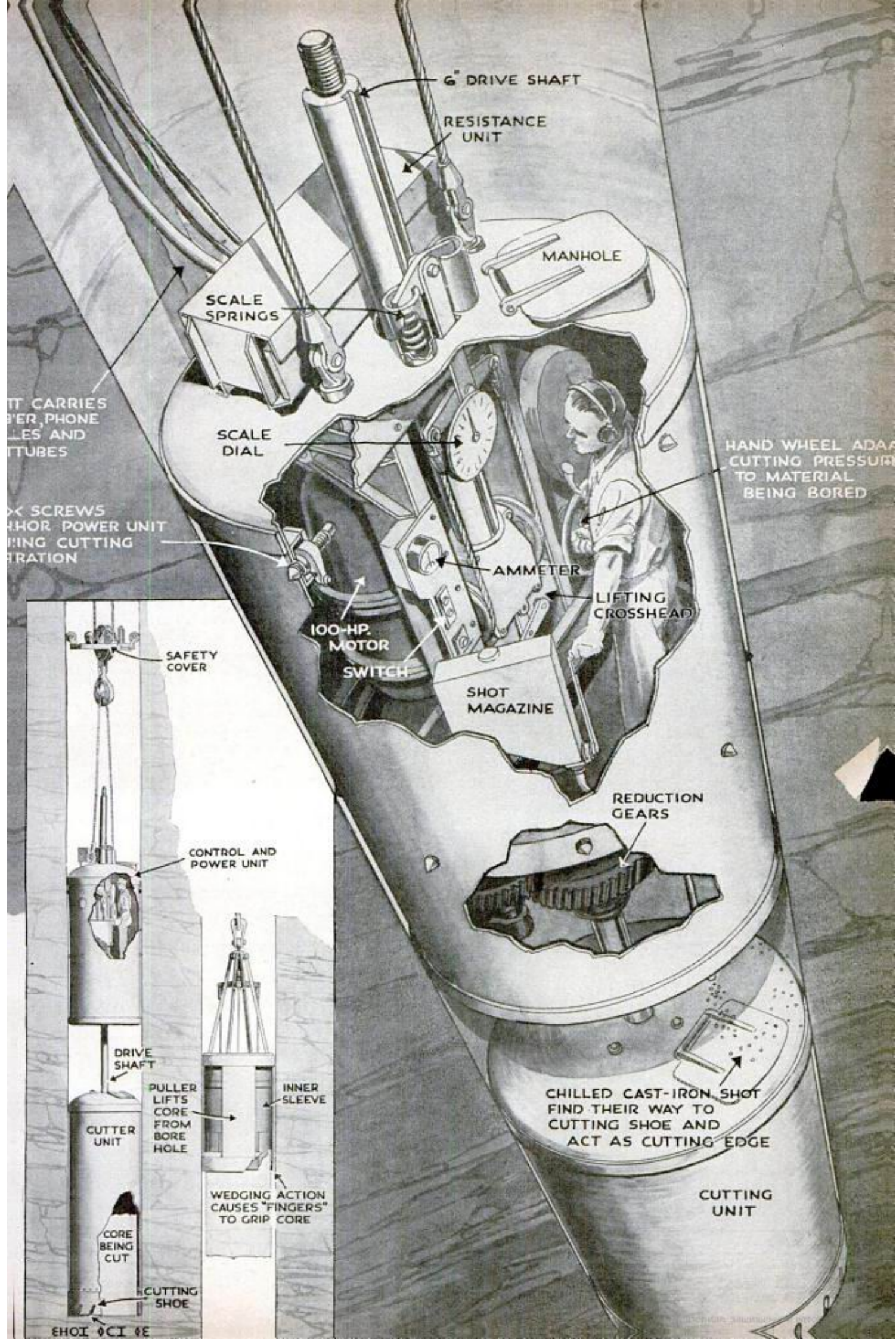
By **ANDREW R. BOONE**

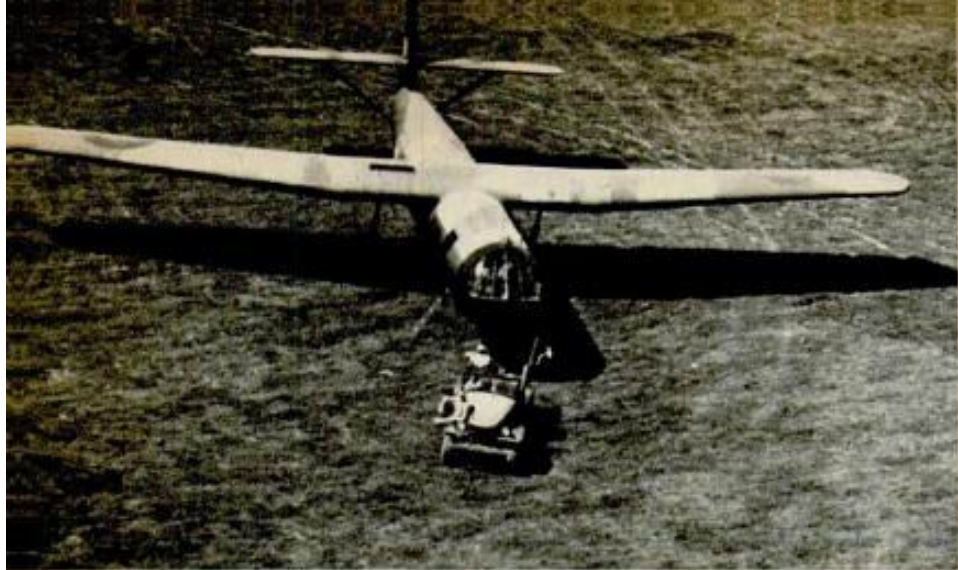
Drawing by **B. G. SEIELSTAD**

AN EARTH-GNAWING machine that contains within its cylindrical metal hulls all the equipment necessary for eating its way through solid rock is reshaping the art of mining. Already the machine has chewed two deep holes opening new shafts into California and Minnesota mines, and today, 1,000 feet below the earth's surface at Hurley, Wis., it is cutting a mine shaft down toward the 3,000-foot level of an operating iron mine. So quietly has this coring device been developed that few outside the mining business know of its existence.

Most core drills, turned from the surface by long shafts, take samples measuring only a few inches in diameter and can probe only to limited depths. This rock eater, invented by Branner Newsom, a California mining engineer, knows no limits. Suspended by steel cables, it can push down as deep as mines can be operated. Anchored against the smooth wall of the hole it digs, the rock corer and a companion lifting device gulp up great columns of the hardest rock in chunks 16 feet long and 5½ feet thick.

For the first time in mining history, explosives are not needed to sink large shafts. An inexpensive wooden superstructure prevents the power end of the corer from



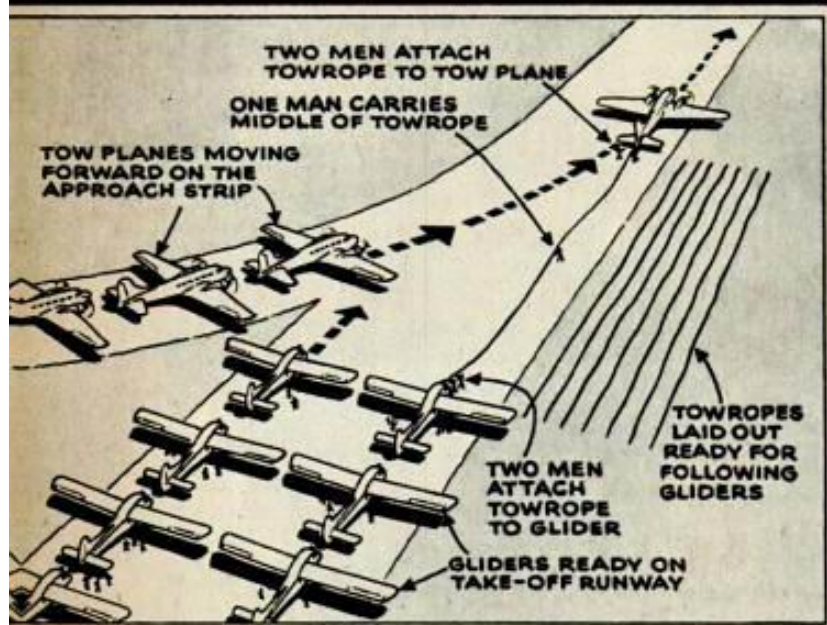


Towed by a tractor, a British Horsa goes back to its hangar after a flight. Wings and fuselage are mottled above, painted jet black below

occupants to talk without raising their voices.

To lose altitude rapidly, the pilot raises a pair of solid flaps called "spoilers," which kill the lift of the wings. A spectacular innovation, illustrated on this month's cover, has recently been tested for checking a glider's forward speed. It consists of a horizontal parachute, unfurled from the glider's tail in midair, and released or retained as the craft strikes ground. With such quick-landing aids, a

SOME OF THE JOBS THAT GLIDERS ARE BEST FITTED TO DO

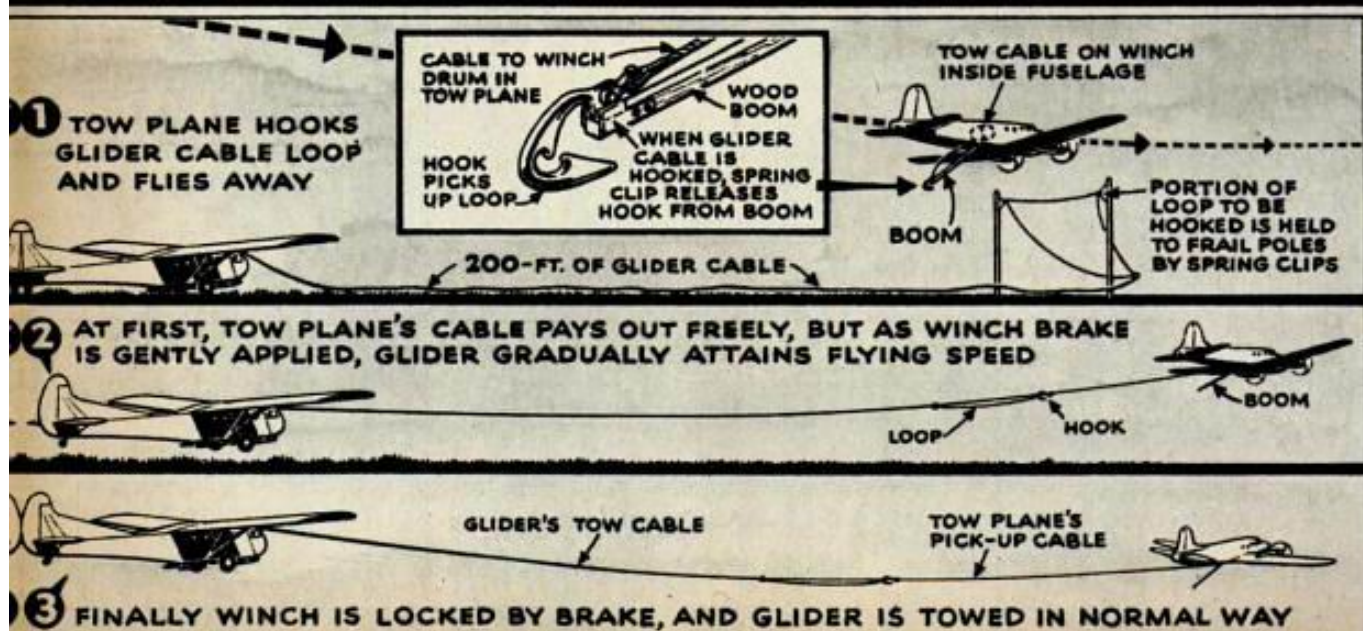


High-speed launching puts fleet quickly in air



Troops land in enemy's rear . .

Pickup recovers gliders from fields where tow planes cannot land



tree-skimming approach exploits the element of surprise to the fullest.

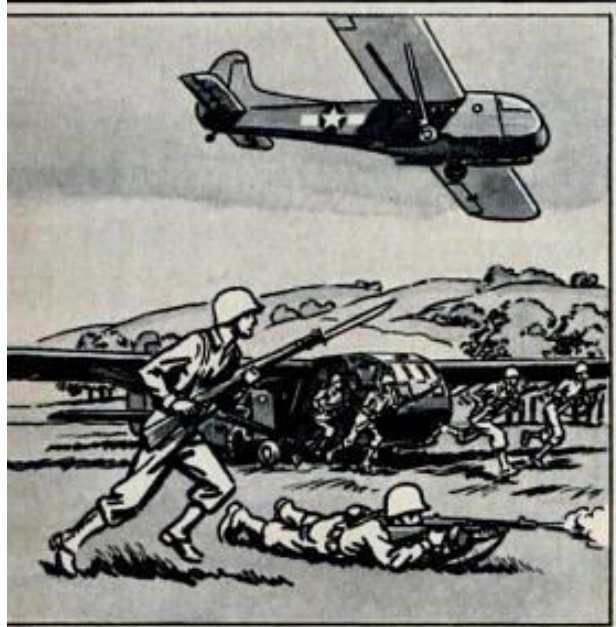
Gliders of the U. S. Army Air Forces now range in size from tiny, colorful training craft, called TG's, up to the big green CG-4A, which doubles as a carrier for troops and for cargo. Pending development of still larger and more formidable gliders, the CG-4A—currently in mass production—is the Army's standard type. As a troop carrier, it holds 15 men, including pilot and copilot. Alternatively, it transports a jeep and six men. Other cargoes may consist of 37-mm. antitank guns, 75-mm. pack howitzers, motorcycles, food, and ammunition. Overall, a CG-4A measures about 84 feet in wing span, and 48 feet in length. In addition to doors

at its sides, its whole nose may be opened to discharge men and equipment.

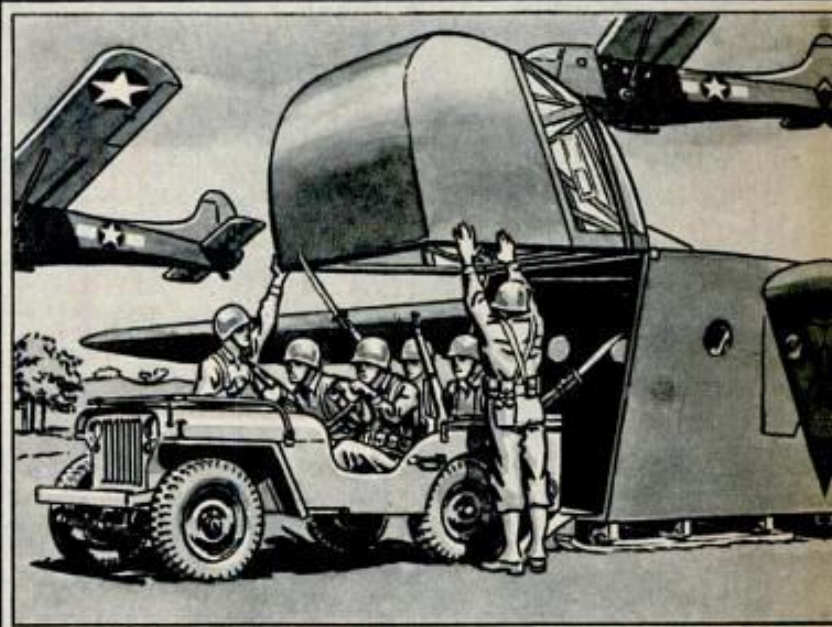
Military experience has demonstrated limitations as well as advantages of gliders. You can't get something for nothing by hitching a glider behind a plane. It takes power to pull it. Trials seem to confirm the conservative opinion that, for long hauls, a powered plane alone will transport a load more efficiently.

Nevertheless, gliders appear destined to play an important role in commercial aviation, closely paralleling their special military advantages. Feeder lines, connecting out-of-the-way communities with through airways, can employ multiple glider tows to pick up and let off passengers at any point along the way. (CONTINUED)

... AND HOW THEY ARE HANDLED IN MILITARY OPERATIONS



... together, ready to fight



Jeeps, guns, and supplies carried to the front

Glider models are targets for gunners



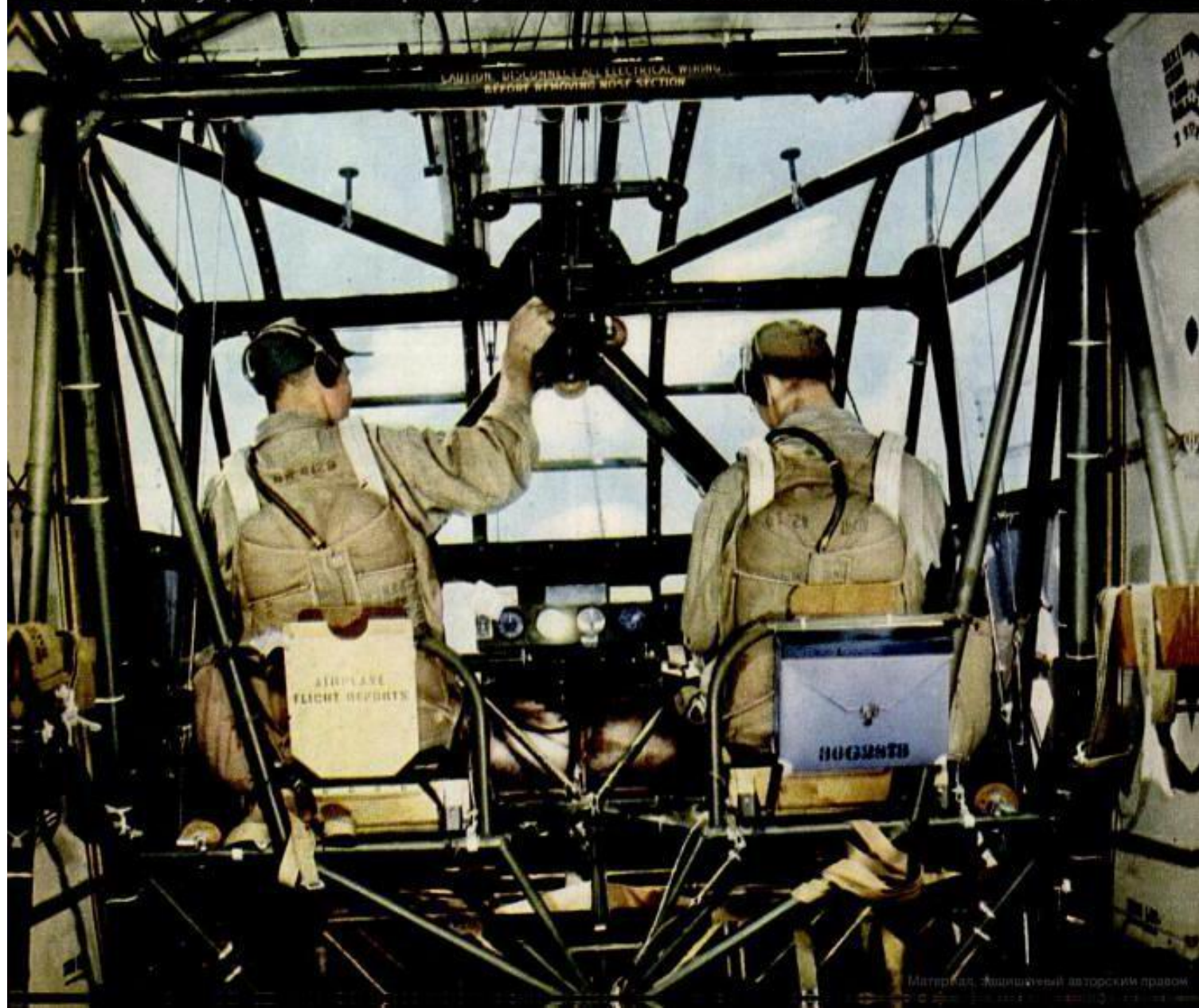
Wheels may be dropped by parachute

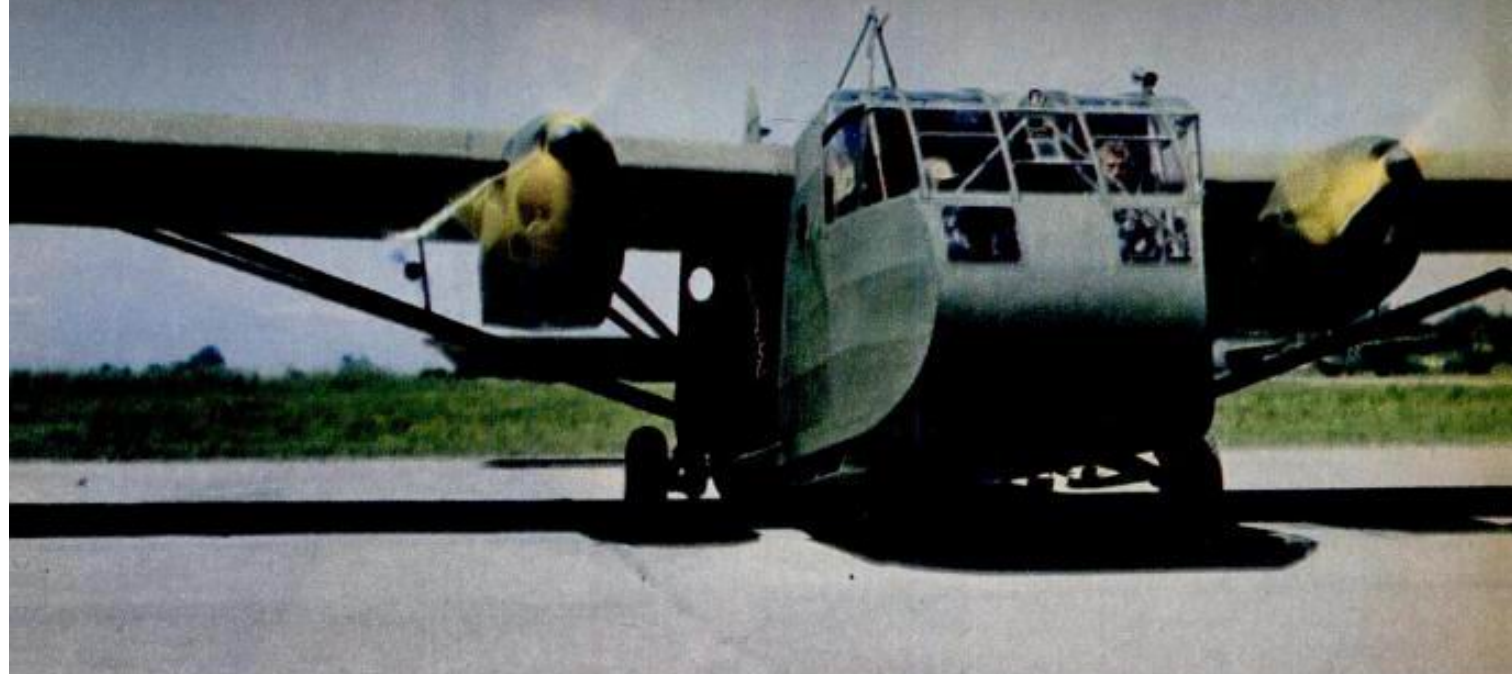




CG-4A is the U. S. Army's standard troop and cargo-carrying glider. With a wing span of 83 feet 8 inches and over-all length of 48 feet, it weighs 4,700 pounds unloaded and carries a payload of about 1½ tons. Fifteen men, counting the pilot and copilot, can ride in its broad fuselage and come out fighting when it lands

Pilot and copilot occupy a fully equipped cockpit in the blunt nose of the CG-4A. A broad, high window gives them full vision of what is going on in the air and on the ground during a tricky landing in enemy territory. In this photograph, the pilot is operating the lever that casts off the towline and releases the glider





"PIG" is the Army's nickname for the powered glider, a hybrid craft produced by mounting detachable engines on a standard glider type. This is the PG-2, a CG-4A fitted with two 175-hp. air-cooled engines that can drive it at 100 miles an hour for delivery from factory without towing or knocking down

Landing gear consists of a pair of small wheels, which, on some models, can be dropped by parachute after the take-off. These are supplemented by a set of skids resembling sled runners, seen under the nose of the CG-4A below. The tripod on top is part of the mechanism for lifting the hinged nose



POPULAR SCIENCE

25¢
FEB

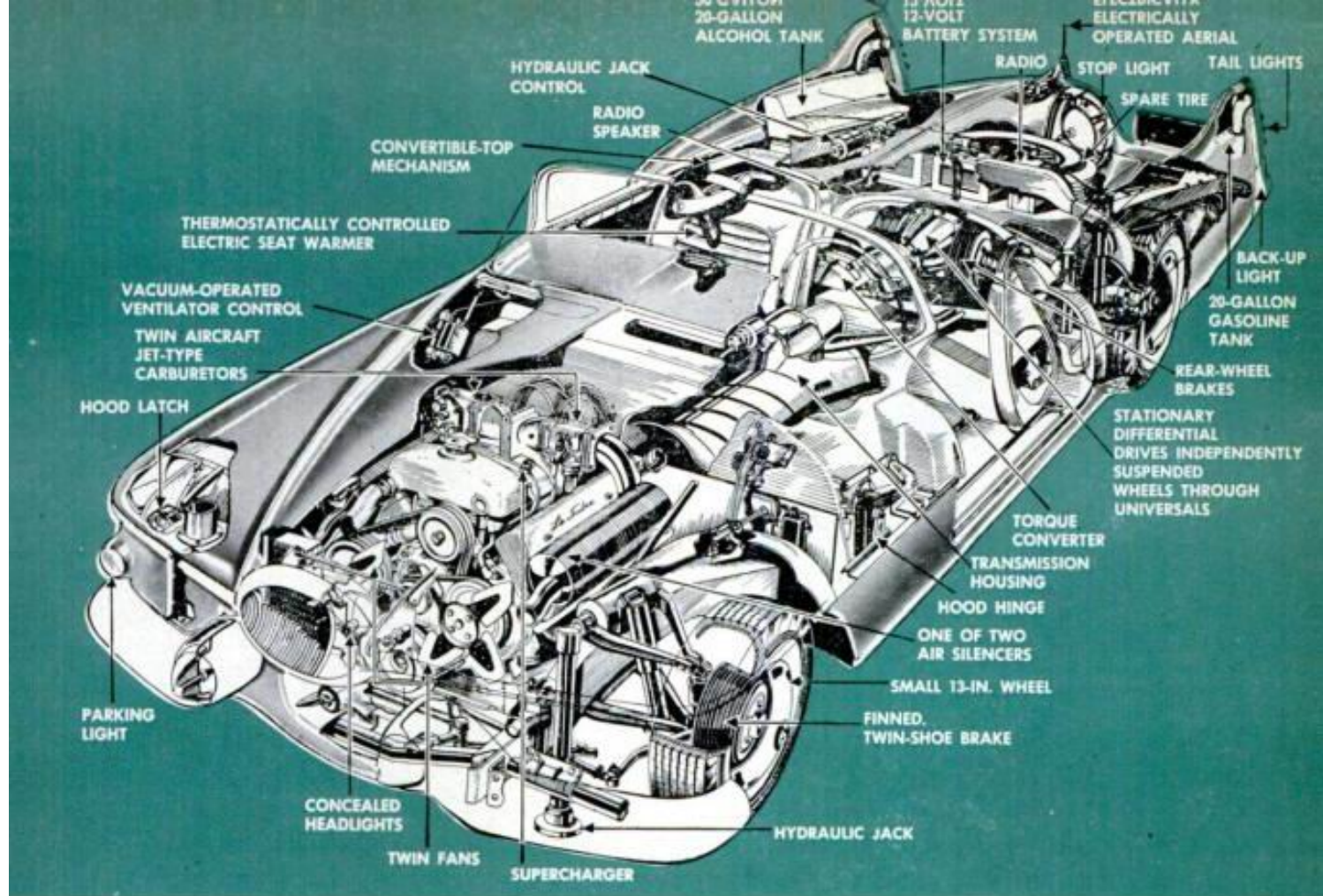
MONTHLY



WHAT IS THE TRUTH ABOUT **AMERICA'S WAR GLIDERS?**

PG.
94

Материал, объединяющий в себе...



YOU can't buy this beauty, but you can expect to see many of its features turning up on cars in the years to come. Now being completed by General Motors, the hand-built, super-styled car will serve as a rolling laboratory for engineers to test out new ideas in design and equipment.

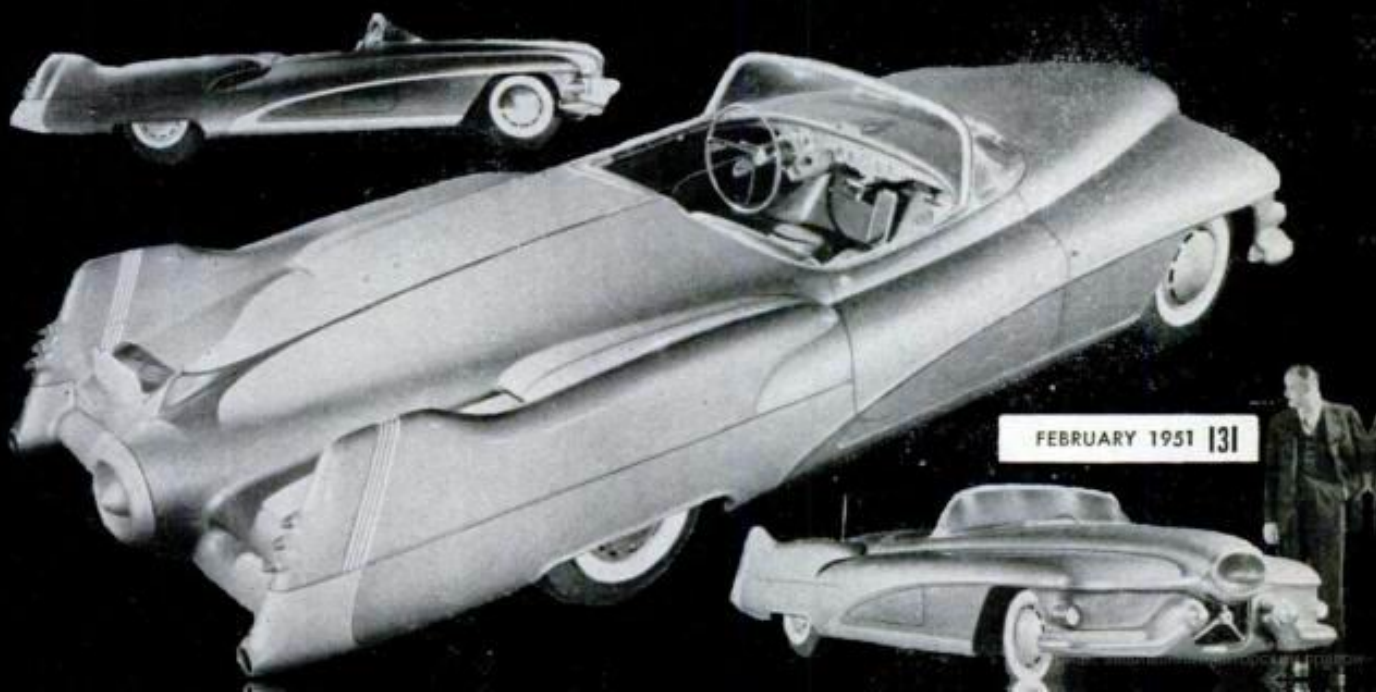
Its special high-compression (10 to 1) V-8 engine plus supercharger is expected

to deliver 300 hp. Built-in hydraulic wheel jacks, electric seat warmers, and a rain-sensitive switch that will automatically put up the top are just a few of today's novelties that may become commonplace tomorrow.

After all, an earlier 1938 GM version was the first U.S. car to boast an electric top, curved-glass windows, and push-button door latches—now taken for granted. **END**

Airscoop nose and twin-finned, jetlike tail show aircraft influence. Long, low silhouette is pro-

duced by 200-in. length, only 36½-in. height. Light for its size, the car weighs 3,000 lb.





Cover drawing by
Reynold Brown

A racing champion designs a tunnel-shaped

By Alden P. Armagnac

PS photos by W. W. Morris

BECAUSE an inquisitive experimenter sawed a boat in two, tomorrow's ocean voyagers may enjoy unprecedented speed and comfort aboard liners of new design.

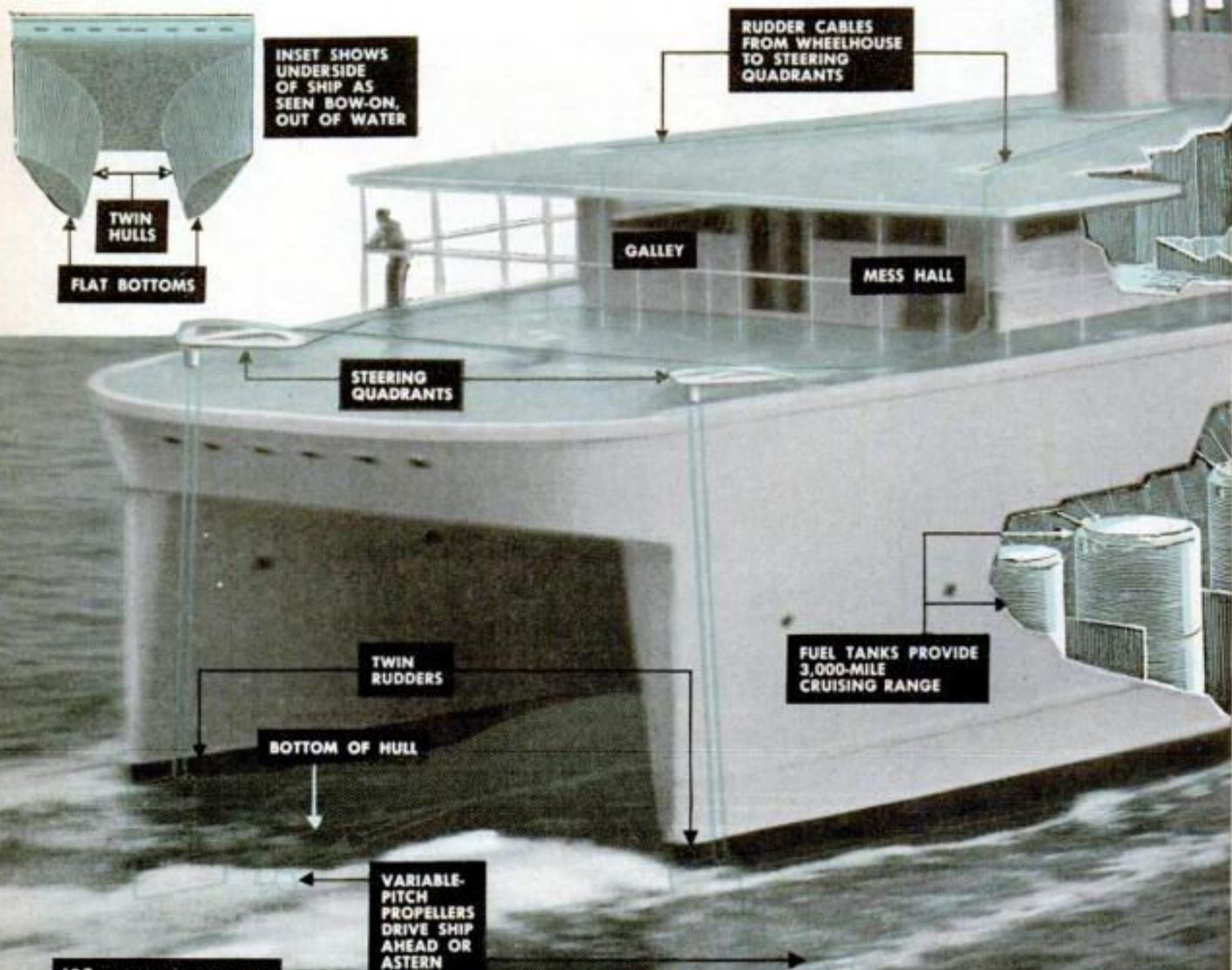
The man with the saw was Gar Wood, silver-haired king of American motorboat racing. He sliced a conventional boat hull

down the middle, transposed the two halves, and joined them with a superstructure. And he found he had a better boat.

Now the 68-year-old inventor envisions a superliner applying this design—a giant floating tunnel 900 feet long. Twin hulls would be bridged by decks with accommodations for at least 4,000 passengers. Four steam turbines, totaling some 120,000 hp., would propel the bizarre ship at 35 to 36 knots, a

Interior features of Gar Wood's seagoing twin-hulled yacht *Venturi* are seen in cutaway sections of PS air photo below.

How ship is run is shown, in inset on opposite page, by artist's drawing of controls in wheelhouse, with Wood at helm.



Gar Wood's Sea Speeder

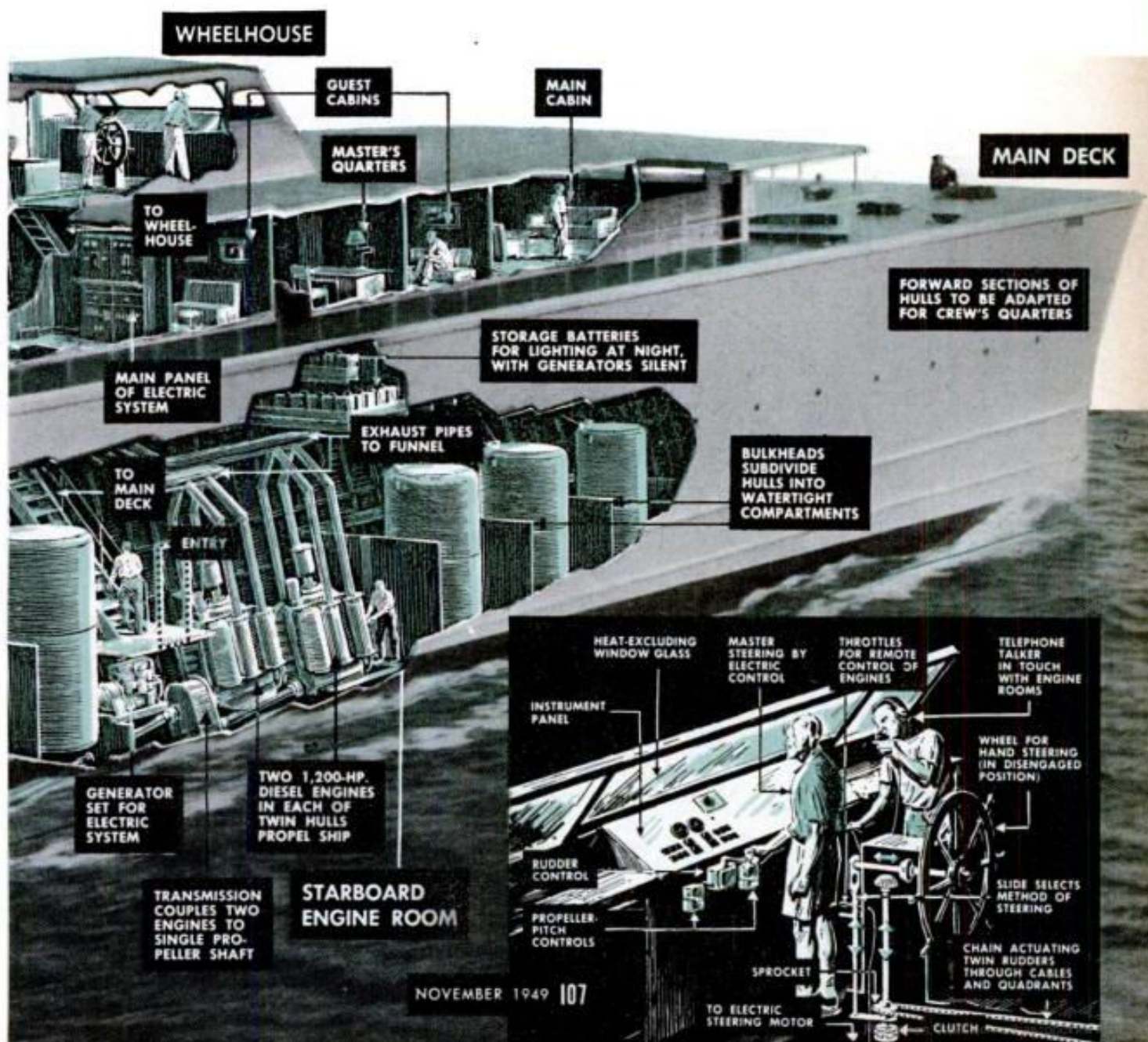
boat that looks like an inventor's pipe dream—but works.

phenomenal pace for commercial vessels. (The 80,000-ton *Queen Mary* uses 200,000 hp. to carry about 2,000 passengers at a top speed of 32 knots.)

Free from rolling, pitching, and yawing, the "tunnel boat" would provide new comfort for its passengers. Since these motions slow an ordinary ship, their absence would contribute to the new liner's top speed and to economy of power and fuel.

A king-size working model, Gar Wood's \$600,000 dream boat *Venturi*, demonstrates the principles of his new design. First publicly exhibited last August in trial runs off Miami Beach, Fla., this radical craft currently serves as a floating laboratory to test and perfect its builder's plans.

Pictures don't prepare you for the impressive size of the big, white, brown-roofed, silver-funnelled ship. The *Venturi* ▶



10 Turboprops Power Giant Flying Boat



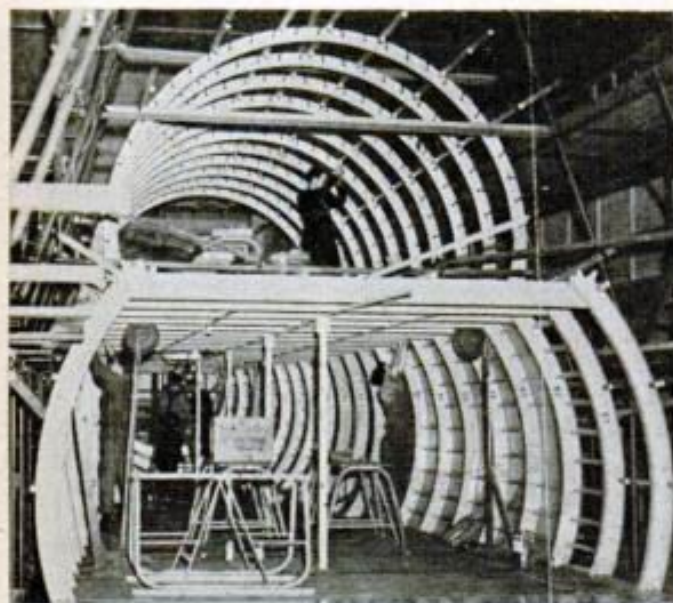
Model of 10-engine, long-range flying boat shows the high wing and single fin and rudder.

BRTAIN'S faith in flying boats and turboprop propulsion is borne out by the huge Saunders-Roe 10-engine Princess®, now nearing completion at Cowes, Isle of Wight.

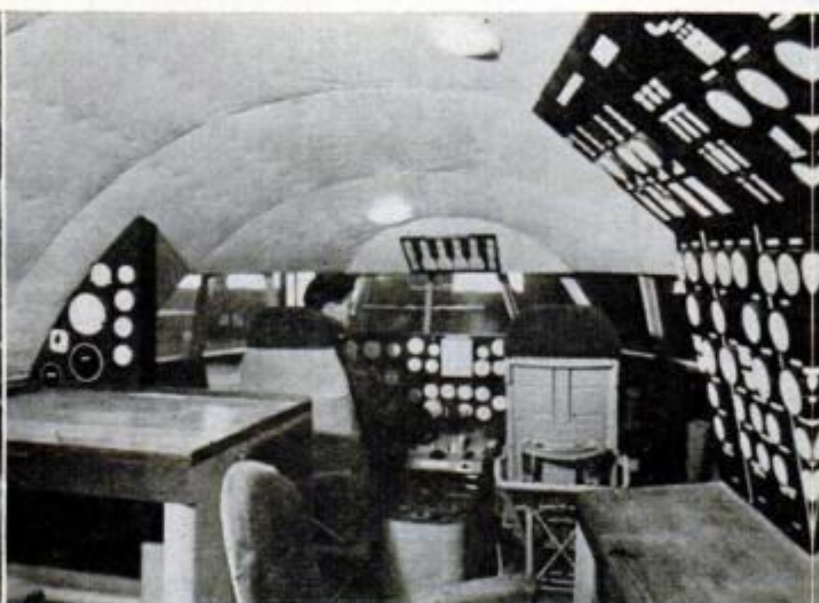
Designed for flights across the Atlantic to South America, the SR/45 will accommodate 85 passengers, plus a crew of 14. The latest in aerial luxury planning, the plane

will have quarters with the comfort and privacy of an ocean liner's cabins. Provisions have even been made for a miniature nursery, complete with toys and sandpit.

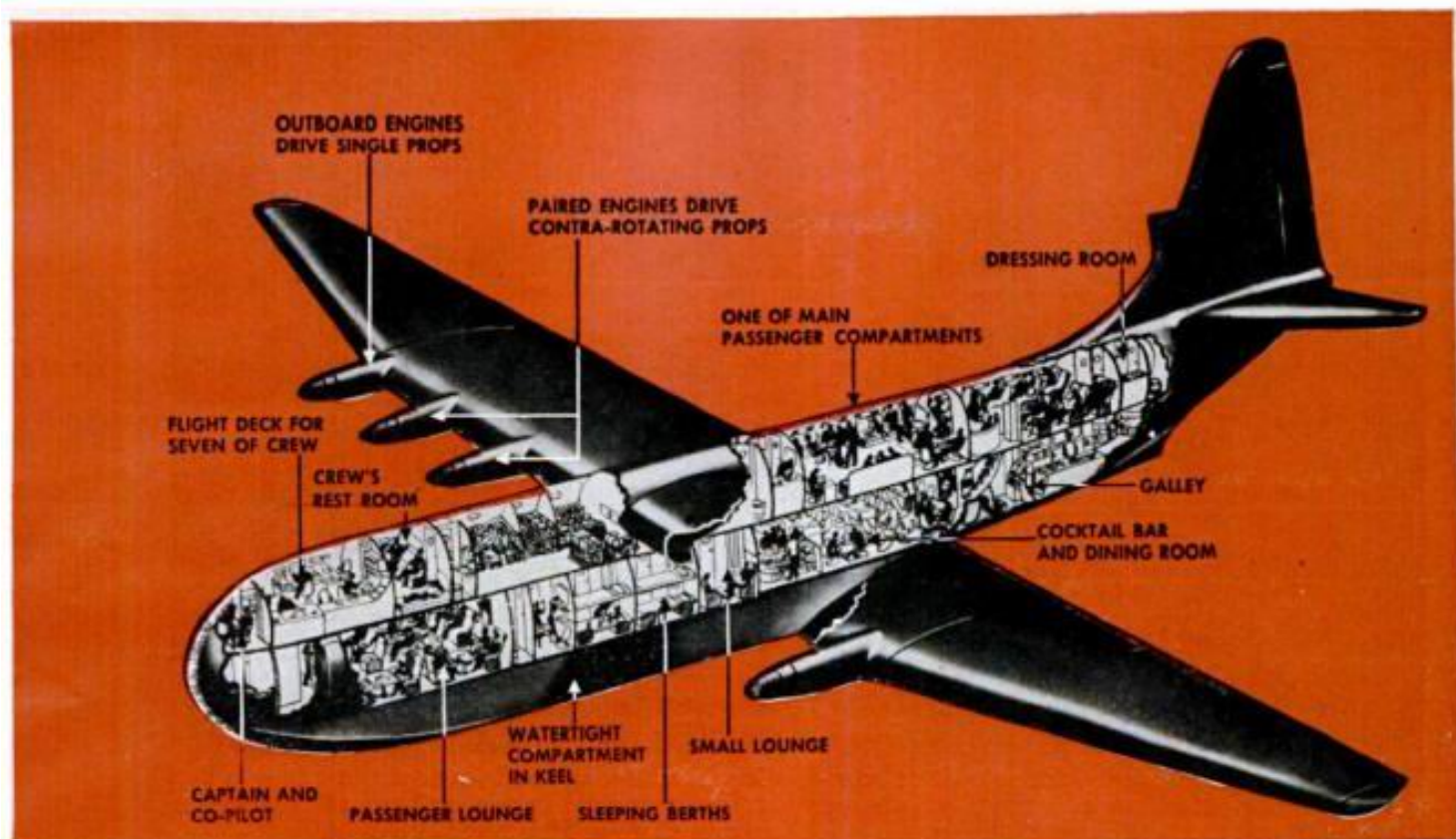
The new flying boat is of double-deck design, similar to that of the U. S. Boeing Stratocruiser®. It will be powered by 10 Bristol Proteus® turbine engines, driving 10



Finishing touches are put on skeleton of the double-bubble fuselage. Hull of the flying boat will be 150 feet long; wingspread will be 220 feet. Landing floats will retract into wings.



This view shows roominess of the pilots' cockpit and the control room. Flight crew of the plane will include five stewards. Plane's decks will be connected by stairways fore and aft.

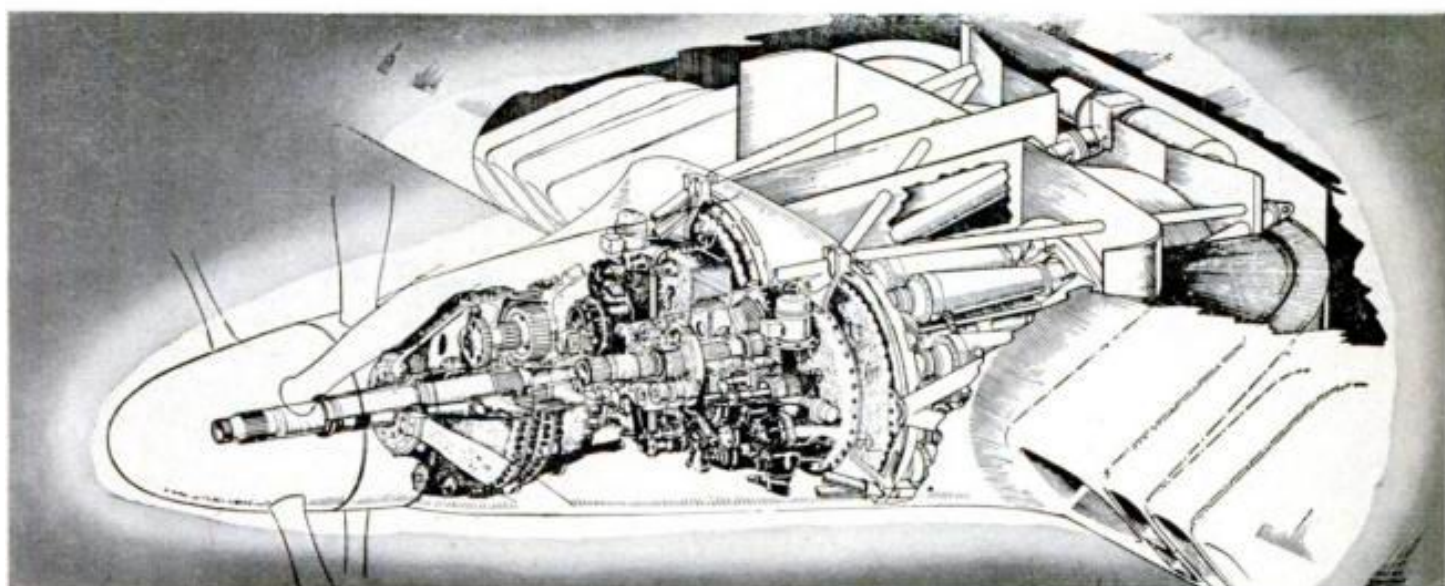


Luxury accommodations are previewed in this cutaway of Princess, now under construction.

propellers, with a total of some 35,000 hp. Eight of the engines are in pairs, each pair driving a pair of contra-rotating propellers; two single engines and props are in outboard positions. The plane will cruise at 380 m.p.h., and will have a still-air range of 5,500 miles. Even at that extreme range, the payload will be between 20,000 and

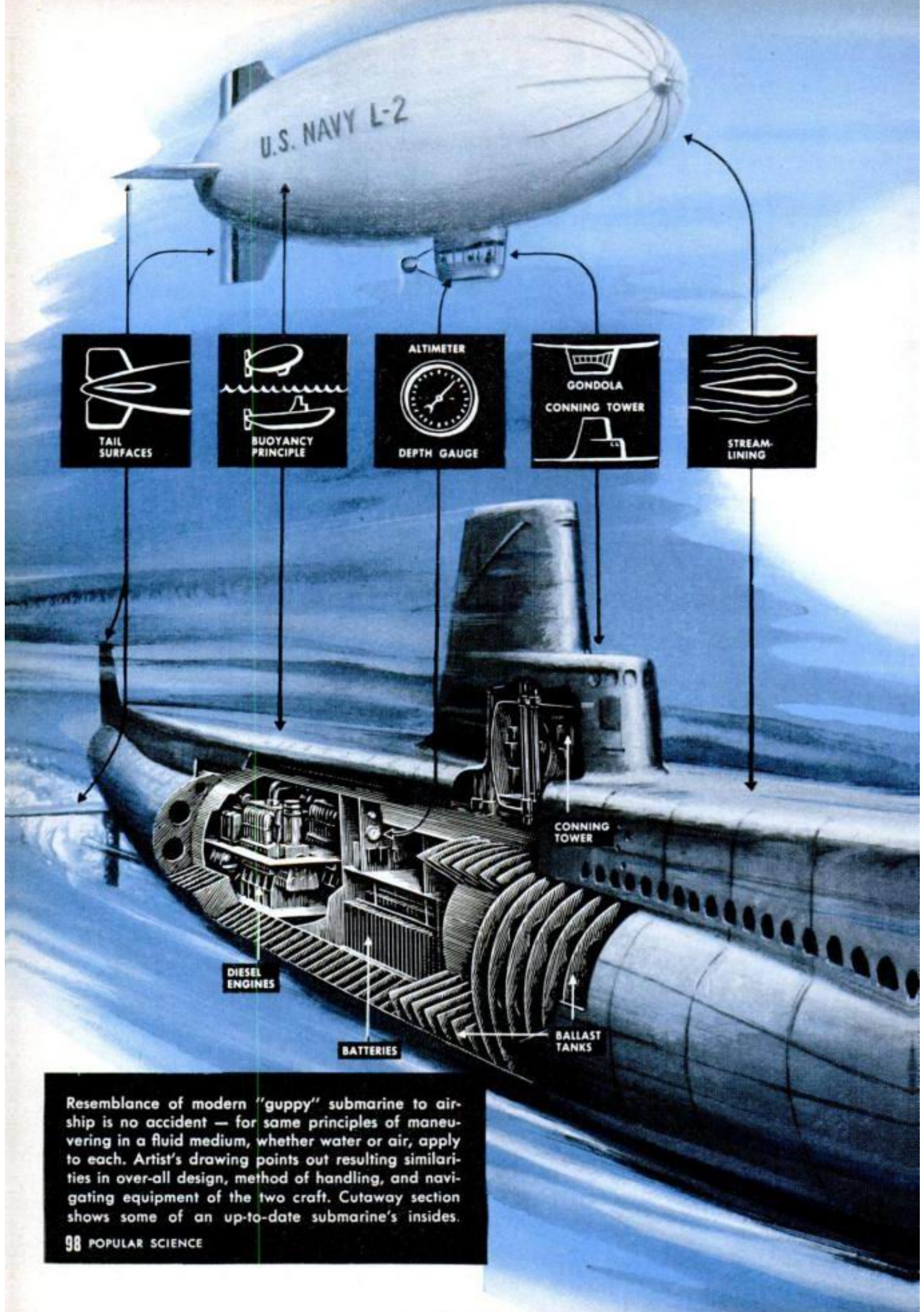
22,000 pounds. In case of a forced landing, watertight compartments will give buoyancy.

Capable of flying at 40,000 feet, the plane will maintain cabin pressure equal to that at 8,000 feet. Three of the big flying boats are under construction, at a total cost of about \$20,000,000. The first of the Princesses is expected to fly early in 1951. **END**



Sectional drawing above illustrates how two Bristol Proteus turboprop engines are coupled to drive the SR/45's contra-rotating propellers. There will be four of these double engine jobs

in the inner wing positions, with two single engines in outer positions. The 10 engines will develop a total of about 35,000 hp. and give the Princess a cruising speed of 380 m.p.h.



Resemblance of modern "guppy" submarine to airship is no accident — for same principles of maneuvering in a fluid medium, whether water or air, apply to each. Artist's drawing points out resulting similarities in over-all design, method of handling, and navigating equipment of the two craft. Cutaway section shows some of an up-to-date submarine's insides.

High speeds submerged and a long-distance nose
make them the deadliest warships known—
but it takes better men to run them.



Cover by Reynold Brown

New Subs Are Undersea Aircraft

By Perry Githens

*PS photos on location by W. W. Morris
Drawings by Ray Ploch*

LOOKING at the U.S.S. *Tusk*, you wouldn't guess this waterborne bomber to be one of the most important warships in the world. She's as sleek as a wet seal: only the conning tower breaks the smooth line of her deck. There isn't a weapon in sight. In fact, the biggest guns aboard, when I visited the *Tusk* at the U. S. Submarine Base at New London, Conn., were some .45 pistols and a 12-gauge shotgun.

It isn't guns that make the *Tusk* deadly. It is the new thinking and equipment housed in that innocent-looking hull. The

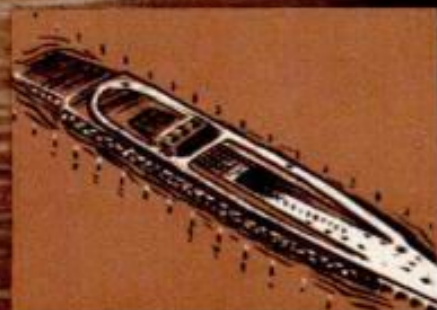
conning tower is crammed with electronic consoles and stacks that can tune in a target or sense a danger miles away. Machinery to drive the ship deep, far, and fast. Machines that make torpedoes, those original guided missiles, think for themselves. Machines by the ton—and 70-odd men whose selection and training make them the best machine of all.

The *Tusk* is one of several fleet-type subs converted into guppy-snorks. So much bilge has been splashed over the words "Guppy" and "Schnorchel" lately that I had better define them.

"Guppy" is simply a code word like OVERLORD or CROSSROADS. The GUPPY project was the development of



Additional proposal to tunnel-trestle crossing is sister span to parallel existing San Francisco-Oakland Bay structure.



Artificial sand islands, flanking channel, would carry tunnel entrances, ventilation plants. Lighted piles would warn ships.



Drawing above shows how concrete slabs would first be laid on pilings sunk in sand-filled trench, to check settlement in bottom mud. Tubes would then be lowered by crane onto slabs. Cross section below shows tubes covered with sand and rocks to hold them in place. The spaces at top and bottom of tubes would be provided for ventilation.



This Bridge Goes Under Water



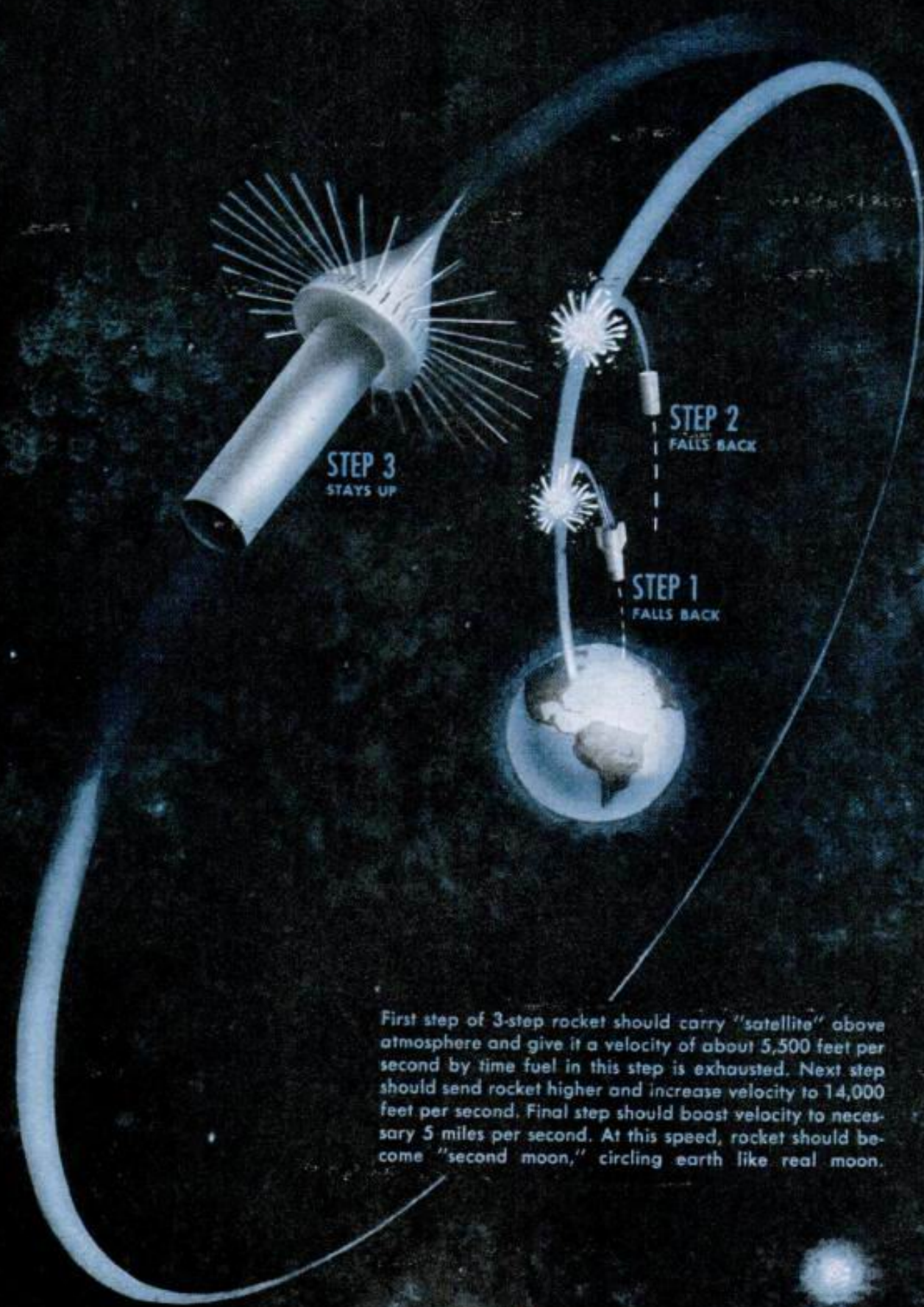
Sand-fill causeway would extend more than mile into bay. Rest of overwater structure would be trestle on concrete columns.

A PREFABRICATED tunnel, built in sections to be dropped to the bottom, may help speed traffic across San Francisco Bay. It is proposed to carry a six-lane highway under the 50-foot navigation channel. Together with several miles of trestle and a mile-long causeway, the structure would stretch $6\frac{1}{2}$ miles between San Francisco and Alameda.

The unique, 6,000-foot-long tunnel would consist of three tubes of reinforced concrete, each 37 feet in diameter and carrying two lanes of traffic. The tube sections would be built in drydock near shore in 200-foot

lengths and sealed at the ends with temporary bulkheads. They would then be towed floating to position, weighted with water, and lowered to the bottom by cranes. With the addition of each section, the bulkheads in the preceding one would be removed, permitting interior work to begin immediately. Special connectors would force the sections snugly together and rubber seals make the joints watertight. Walls of the tubes would be $2\frac{1}{2}$ feet thick.

If approved by Congress, the project will take about five years—and \$172,000,000.



First step of 3-step rocket should carry "satellite" above atmosphere and give it a velocity of about 5,500 feet per second by time fuel in this step is exhausted. Next step should send rocket higher and increase velocity to 14,000 feet per second. Final step should boost velocity to necessary 5 miles per second. At this speed, rocket should become "second moon," circling earth like real moon.

Armed Services Study 'Satellite Vehicle' Idea

By The United Press.

WASHINGTON, Dec. 29—

James Forrestal, Secretary of Defense, revealed tonight the existence of an "earth satellite vehicle program" within the Armed Forces.

He did not say it, but

Is U.S. Building a New Moon?

One rocket has already pierced the earth's atmosphere; a faster one might leave it and circle forever.

By Willy Ley

Author of "Rockets and Space Travel"

Drawings by Jere Donovan

THE Secretary of Defense has co-ordinated "earth satellite vehicle" research by the Army, Navy, and Air Force.

A 3,000-mile rocket-testing range has been requested.

Curtiss-Wright foresees a 10,000-m.p.h. "space ship."

Lockheed's chief engineer says: "Escape from the earth is far closer than most people think."

SUCH revelations made POPULAR SCIENCE editors ask: Is the United States now building a new moon?

No hints as clear as some of these preceded the first A-bomb's shock wave. Space ships, defense officials now say, are "a matter of highest secrecy." So the men who know exactly what's coming up and when are mum or enigmatic. Some of the rumors you may have heard, and some of the headlines, have been preposterous. But, beyond a shadow of possible doubt, American scientists and engineers are working on an "orbit-

POPULAR
SCIENCE



Cover drawing
by Ray Piorch

STEP 3

1,000 LB.	HULL AND PAYLOAD
2,500	FUEL
3,500	TOTAL

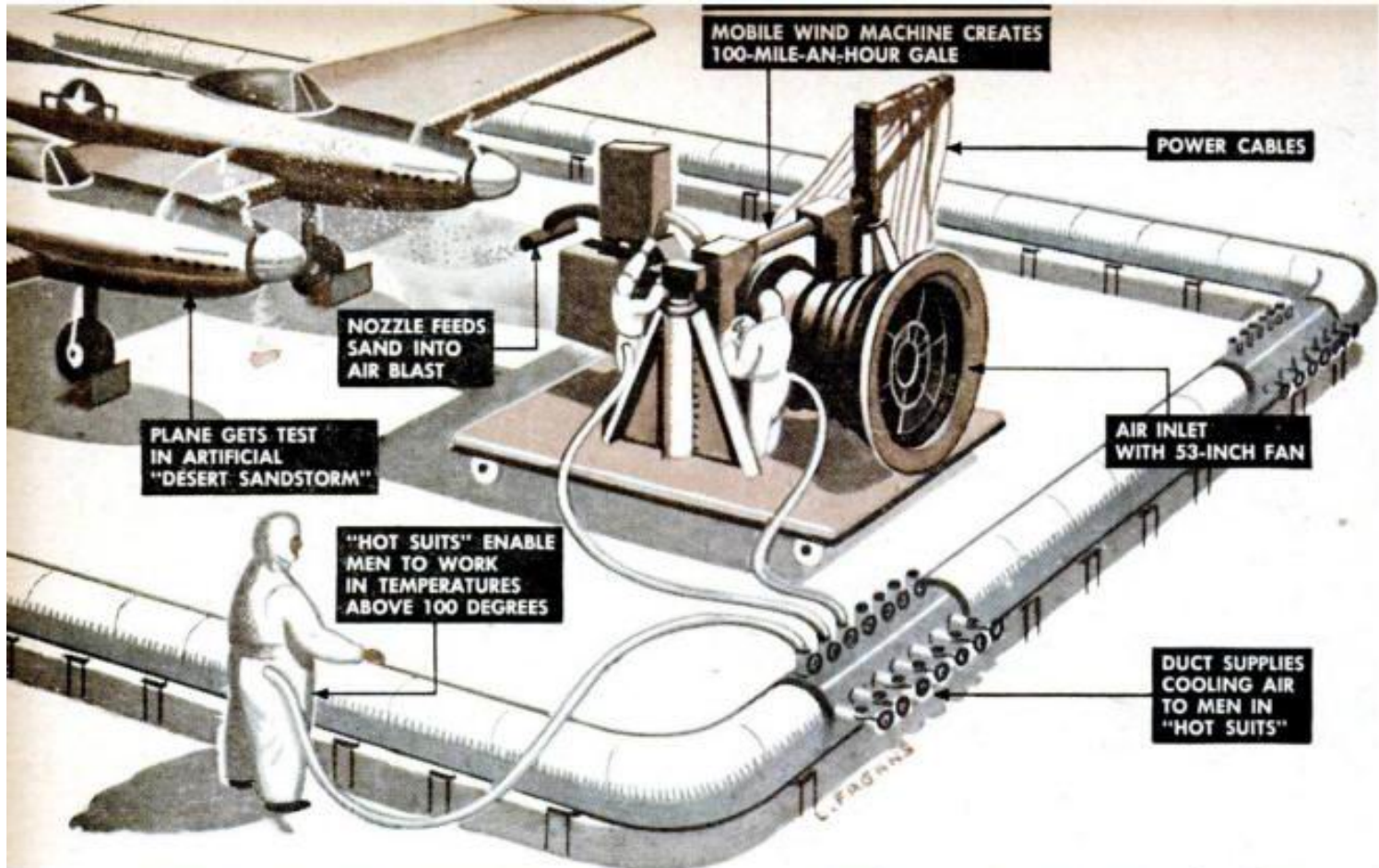
STEP 2

3,500	PAYLOAD
6,500	HULL
25,000	FUEL
35,000	TOTAL

STEP 1

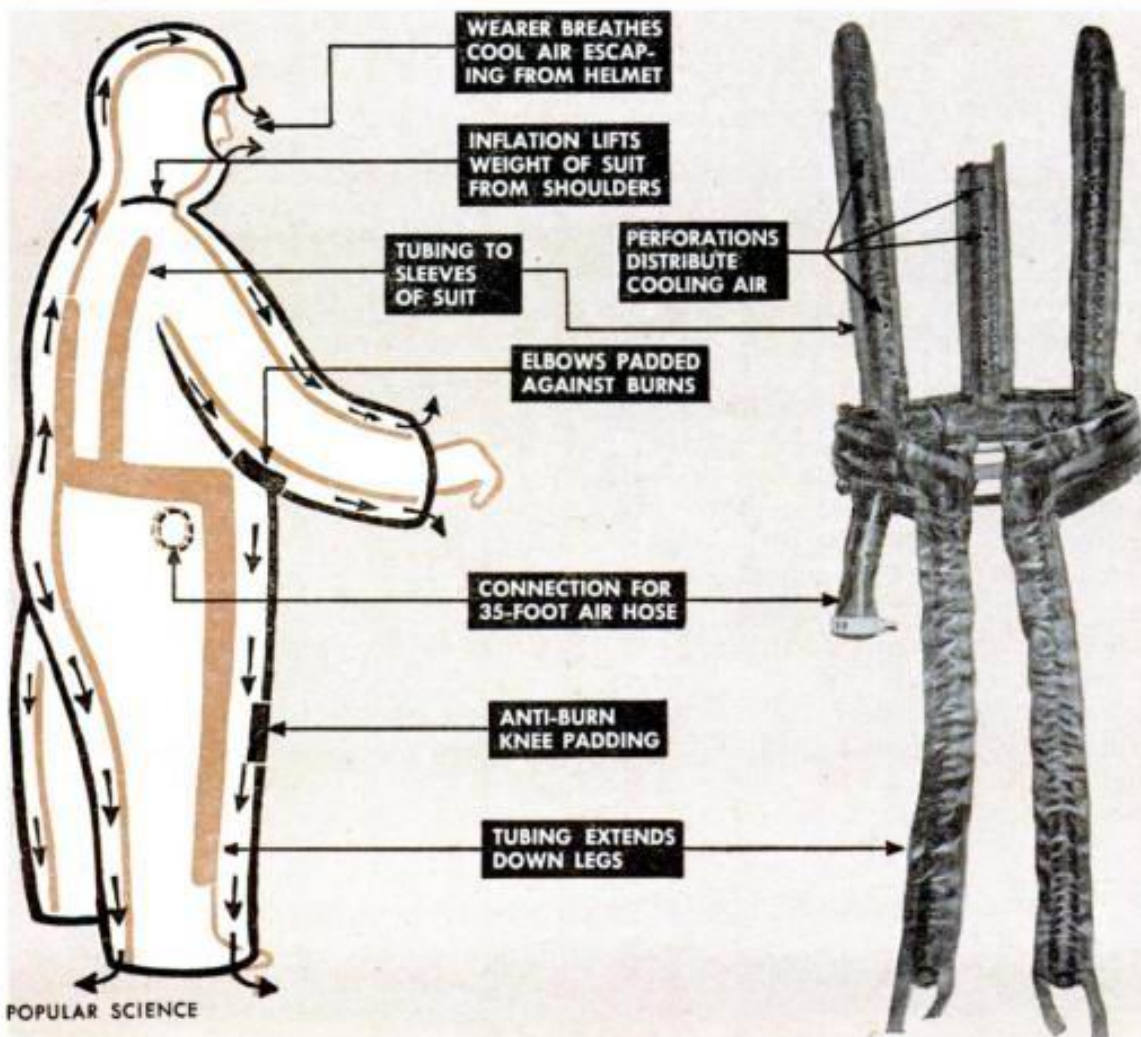
35,000	PAYLOAD
30,000	HULL
162,500	FUEL
227,500 LB.	TOTAL TAKE-OFF WEIGHT

donovan



Equator's heat can be reproduced in hangar with temperatures up to 165°. Above, 100-mile-an-hour blast from mobile wind machine hurls a "desert sandstorm" at spinning propellers

of P-82 under test. So men can work in heat, duct in foreground supplies cooling air to "hot suits," below, fitted with slide-fastened inserts of tubing that can be detached for cleaning.

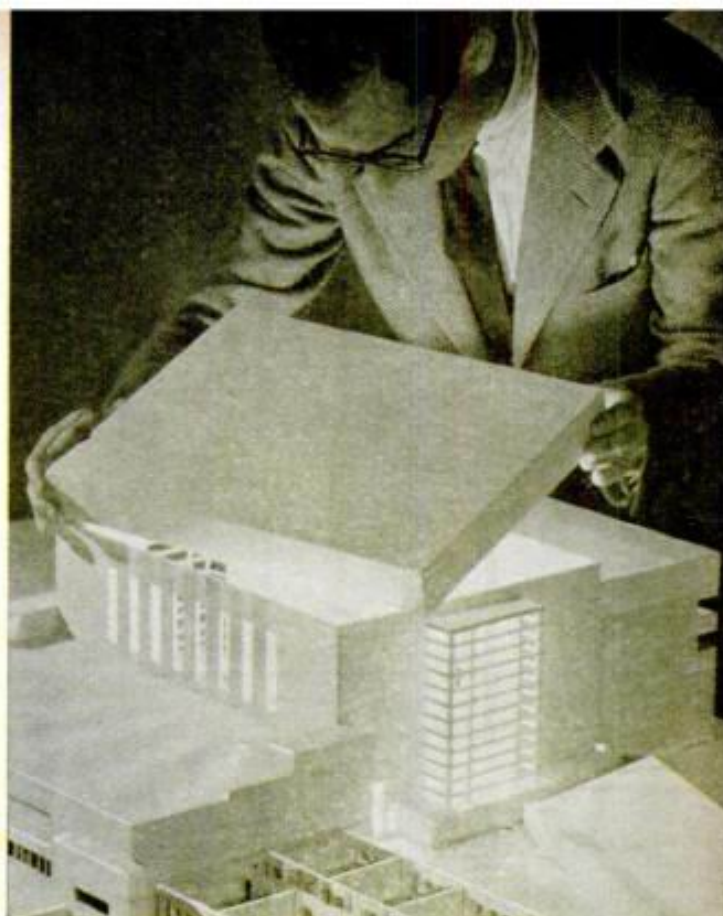


**Popular Science shows you the
innards of Brookhaven's
nuclear furnace.**

U.S. Lights

New

Atomic Pile for Peace



Model shows unusual features of building that houses uranium pile now nearing completion at imposing research laboratory on Long Island.

By Martin Mann

SOMETIME this summer a young man in a sports jacket will twist a few knobs with his eyes fixed on a Geiger counter, then turn and say, "It's critical." The atomic pile at Brookhaven National Laboratory then will be running under its own "steam."

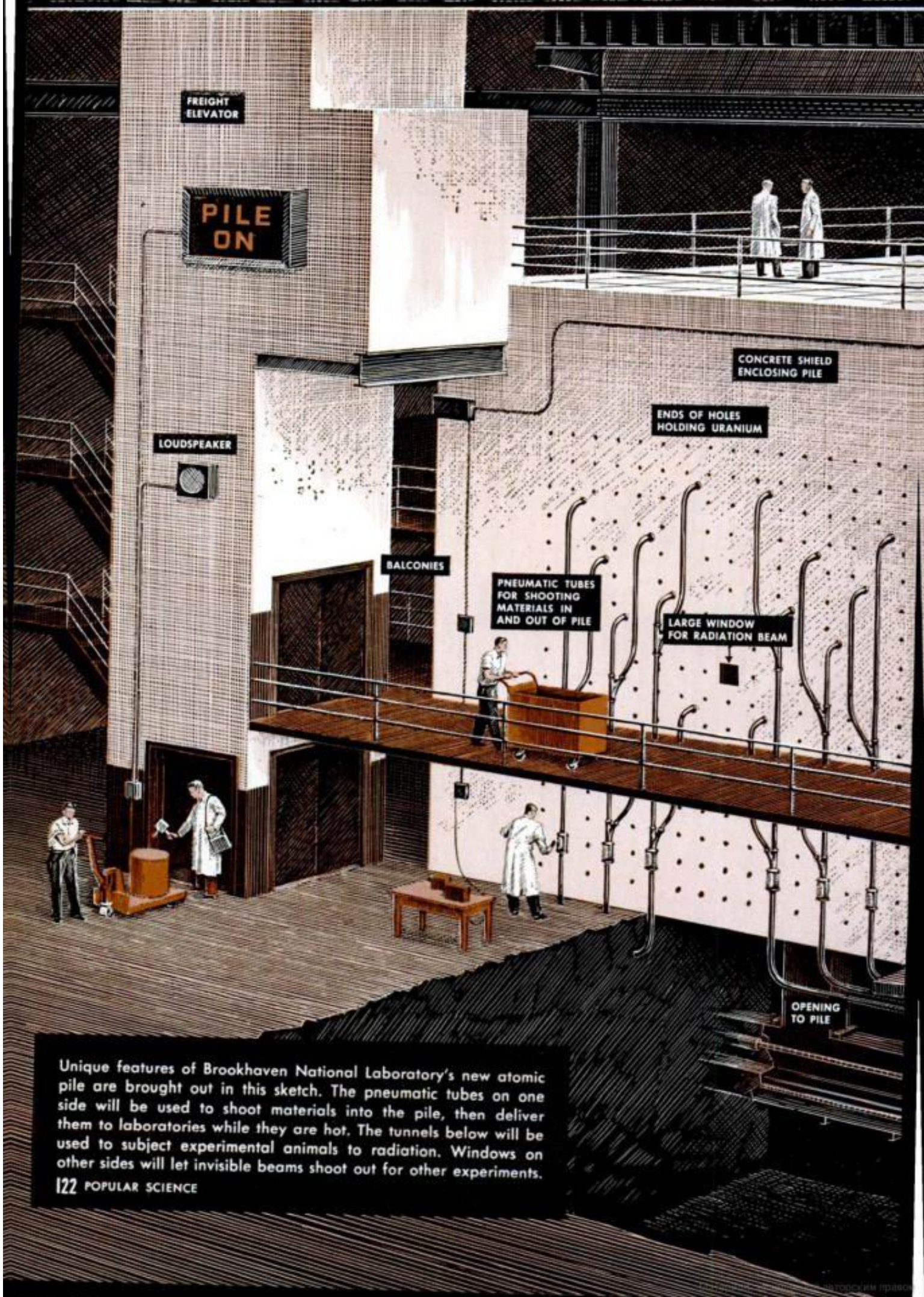
This, the fourteenth furnace ever built to release and control the terrifying forces in the heart of the atom, will be the world's most powerful air-cooled pile. Only the water-cooled giants that manufacture plutonium for bombs at Hanford, Wash., outrange it in the U. S. Brookhaven's pile, however, will not make fuel for bombs, and may not produce any usable power. Instead, it will produce more wrinkles in men's brows—by increasing their knowledge.

Drive out Long Island's Jericho Turnpike 65 miles from New York City to the edge of the duck- and potato-farm country, then

turn off at an inconspicuous sign marked "Brookhaven National Laboratory," and you will quickly spot a big, striped smokestack. It towers above a group of modest frame and concrete-block buildings that house the laboratory. The smokestack and the most imposing buildings are on the side of Rutherford Hill—named for Sir Ernest Rutherford, the British physicist who laid the foundations of nuclear theory.

The biggest building, a light brick structure six stories tall, with two gigantic, green-glassed bay windows, contains the pile. It has two lower wings for laboratories especially designed and equipped for workers with radioactive chemicals. And there is a detached building in the rear for the "hottest" laboratory, where experiments with intensely radioactive substances can be conducted by remote control. Nearby are the fan house, cooling towers, and stack.

No smoke will ever belch from the stack



Unique features of Brookhaven National Laboratory's new atomic pile are brought out in this sketch. The pneumatic tubes on one side will be used to shoot materials into the pile, then deliver them to laboratories while they are hot. The tunnels below will be used to subject experimental animals to radiation. Windows on other sides will let invisible beams shoot out for other experiments.

CRANE HANDLES
HEAVY EQUIPMENT

PILE LOADED
AND UNLOADED
FROM BACK

TOP SHIELD MADE
OF REMOVABLE BLOCKS.

WINDOWS LET RADIATION OUT OF PILE

CONTROL ROOM

PILE
ON

LEAD BRICKS
SHIELD OPEN WINDOWS

SOME PNEUMATIC TUBES
GO DIRECTLY TO
NEARBY LABORATORIES

TROLLEY CAR

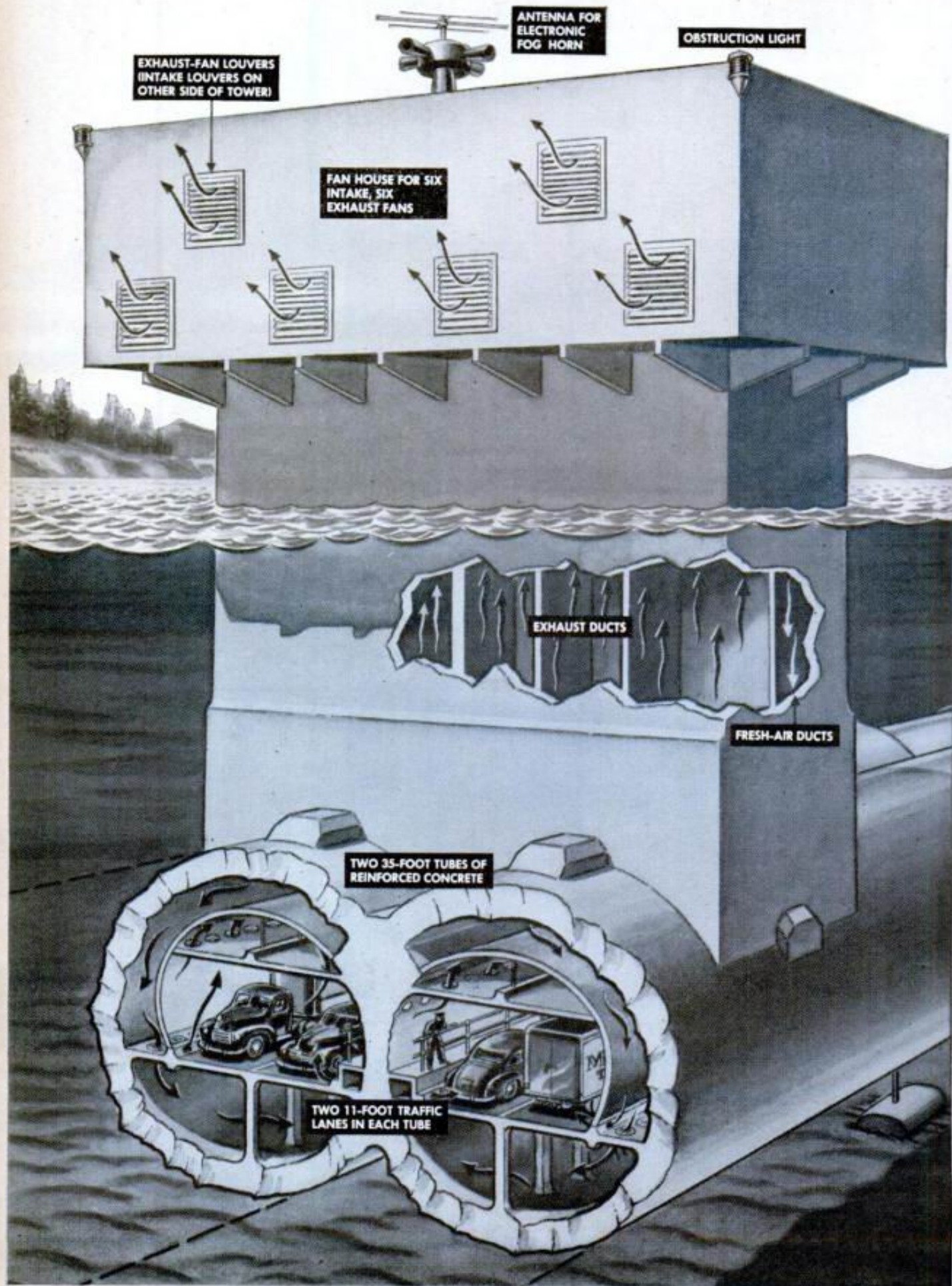
TUNNEL THAT
SENDS ANIMALS
UNDER PILE

INSTRUMENT
TUNNEL

INTAKE PIPE
FOR COOLING AIR

APRIL 1949 123

Ray Brock



Roadway to Float Under Water

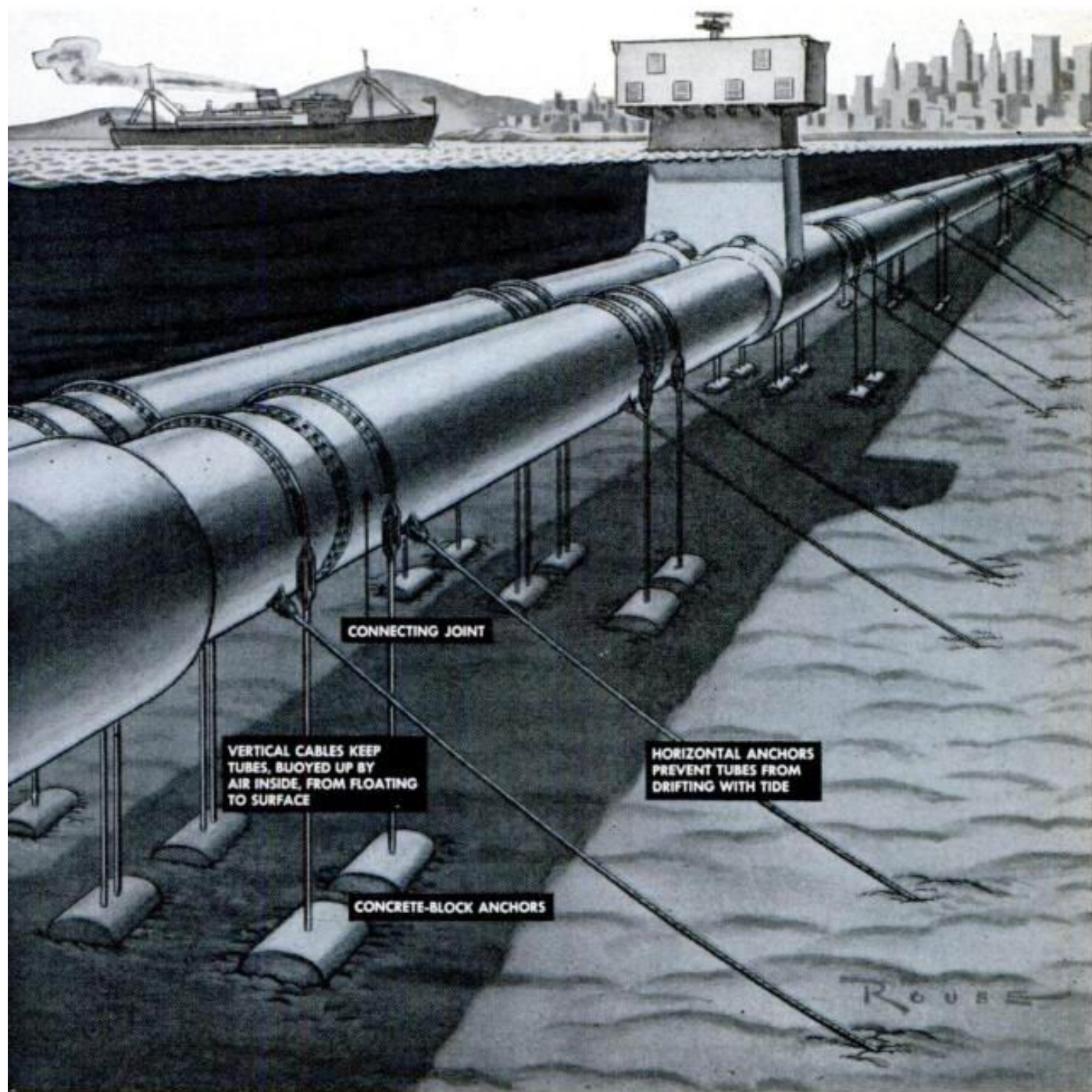
Proposed tubes 2½ miles long would carry traffic 50 feet below surface.

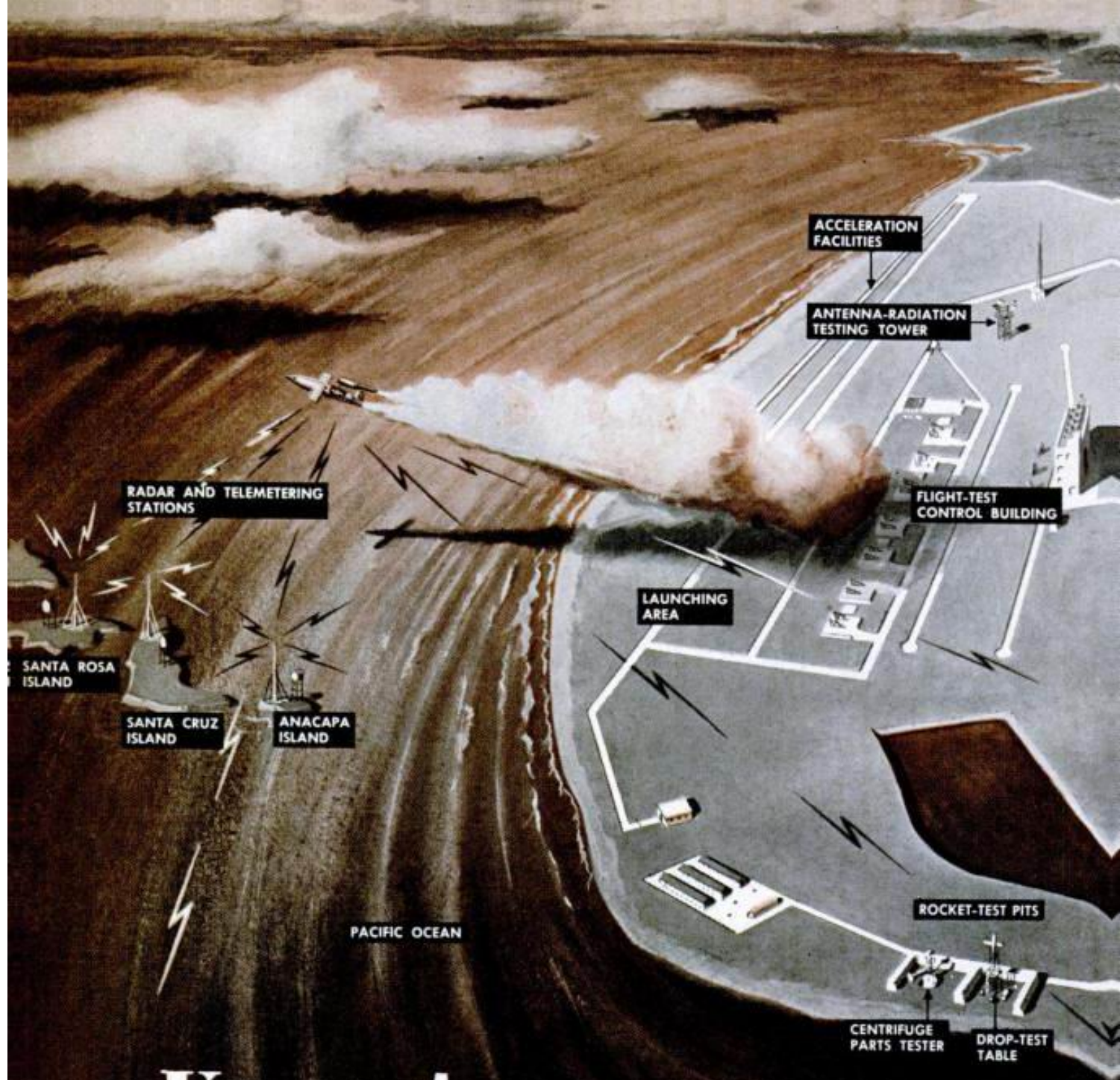
BETWEEN Seattle and Bremerton, Wash., lies an arm of Puget Sound—too wide for a suspension bridge, too deep for a tunnel, swept by tides too high for a floating causeway. Problem: how to build two four-lane highways across that 2½-mile stretch of water. This drawing, based on official

blueprints, shows the proposed solution.

Two sets of these twin tubes would float 50 feet below the surface at low tide, so as not to block shipping. Motor fumes would be blown out and fresh air sucked in through towers rising above waves and spray.

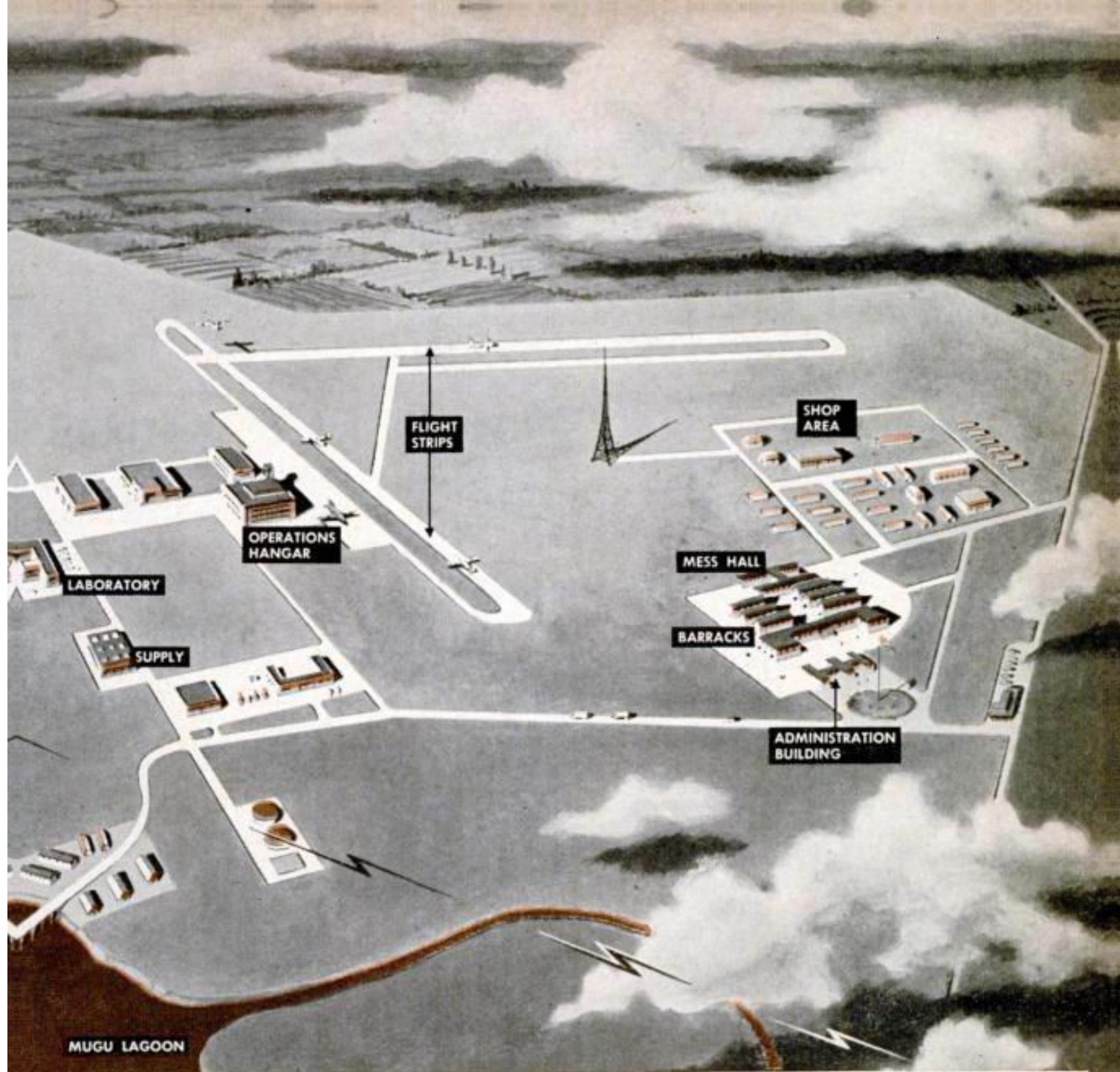
Plans for the \$50,000,000 project, drawn by Charles E. Andrew, of the Washington Toll Bridge Authority, are now awaiting approval by the state legislature.





Keep Away from Point Mugu!

The Navy's test station for guided missiles is being made into the world's biggest proving ground for weapons of push-button war at sea.



By Andrew R. Boone

THE young Naval officer jabs his red pencil at an air map of the California coast. That red dot is now a pin-point target. Its exact position, 100 miles or farther out in the Pacific Ocean, is calculated.

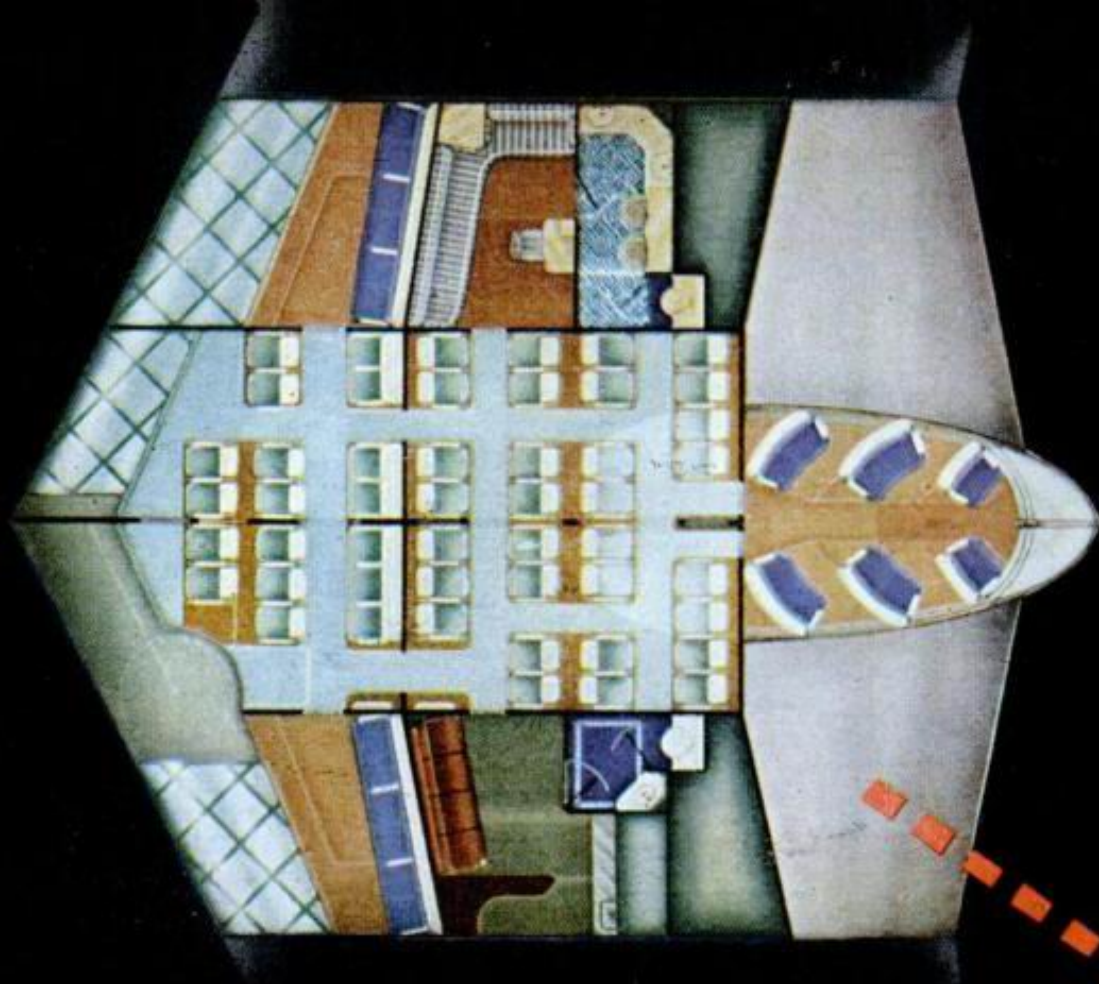
Soon, one of the Navy's secret guided missiles roars from a launcher and arcs high into the sky. If its electronic brain responds swiftly and surely to radioed commands, the missile will plunk into the sea on or very near its mark, far over the horizon.

"At least," the launching control officer tells you, grinning, "we'll scare a helluva lot of sea gulls."

Hitting tiny targets 150 miles away, far

beyond the horizon, is serious business with the Navy's Air Missile Test Center experts at Point Mugu, Calif. Since the station began operation Oct. 1, 1946, hundreds of missiles have smoked seaward. Upwards of \$15,000 drop into the drink as each ends its flight. In time, improvements from these launchings will bring guided missiles that can be fired from surface ships with the accuracy of a 16-inch rifle—but with far greater range and destructive power.

The Navy isn't shooting fireworks for fun. These experimental missiles are not rockets, but miniature planes with wings. They carry instruments that receive their guidance from within, or from a remote station—on land, ship, or plane. They fly toward one of sev-

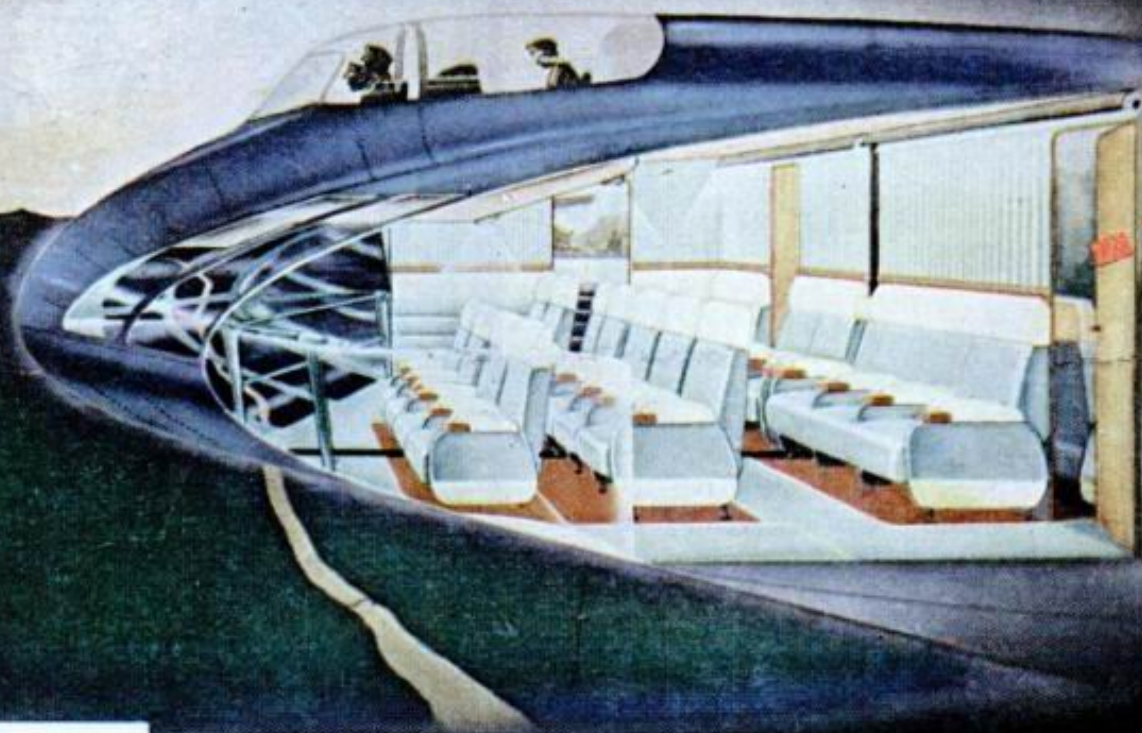


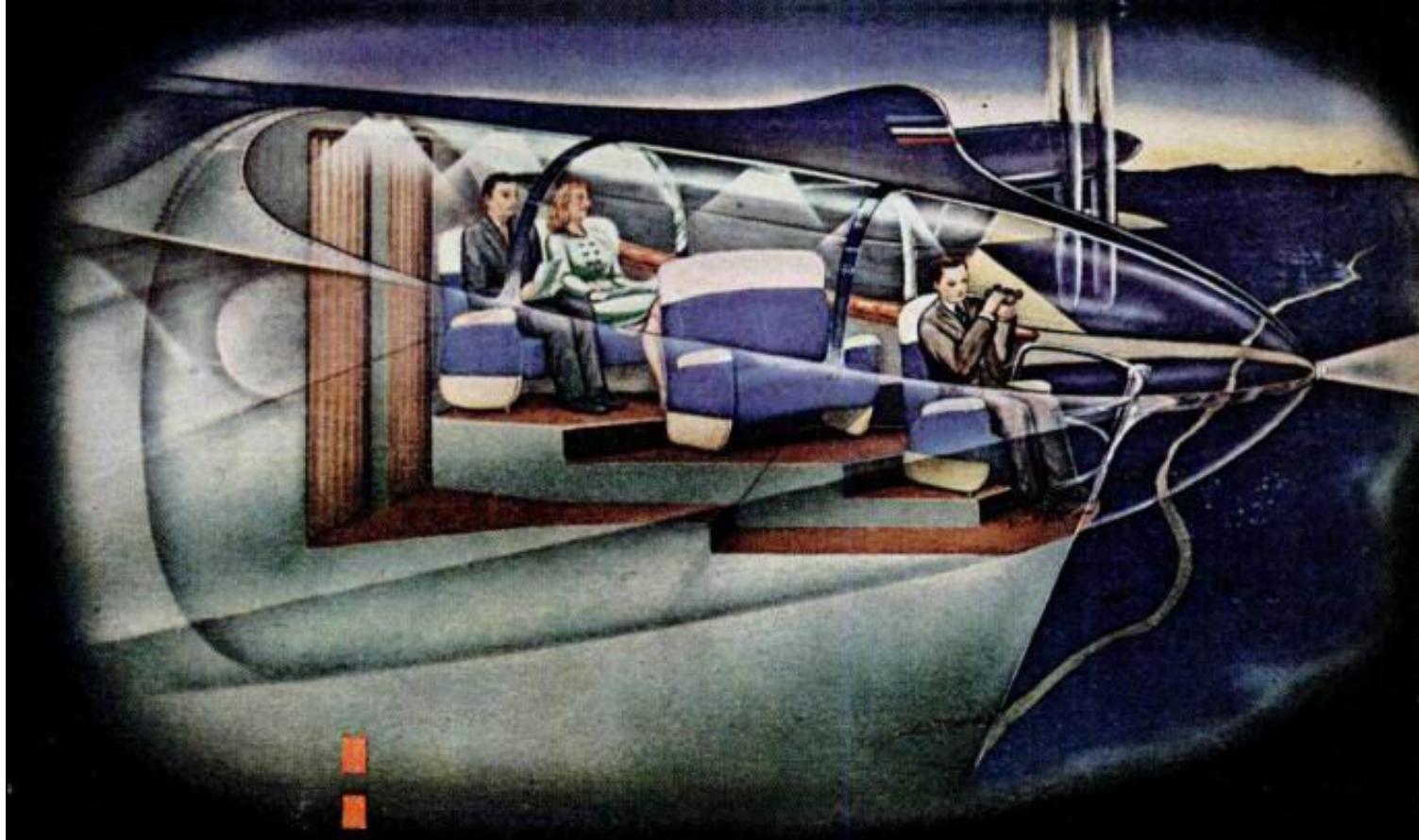
Overhead view shows seating arrangement in proposed all-wing airliner. Forty passengers in

center cabin and the lounges on both sides of it might look out through windows built into floor.

In forward-vista cabin (below), under pilots' and engineer's compartment, 30 passengers would

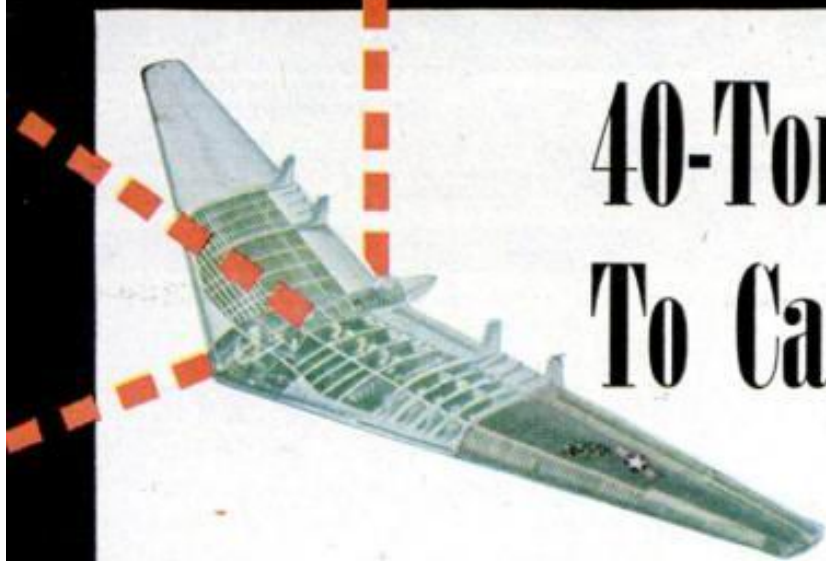
see ahead through transparent plastic reinforced to form the leading edge of the wing at its nose.





Tail cone, in place of the pointed blister in bomber versions of the flying wing, would carry

10 passengers facing backward in three tiers of seats with views to rear, both sides, and overhead.



40-Ton Flying Wing To Carry 80 People

THE MAN who designed the flying-wing bomber has now completed plans for an air liner of the same size and shape.

These drawings show how designer Jack Northrup sees it: a 172-foot wing that would stand 15 feet high and weigh 40 tons empty. Eighty passengers would ride in it, 100 m.p.h. faster—he figures—than in conventional air liners of the same weight and power.

Though Northrup has no plans for producing it soon, the all-wing air liner is no

mere drawing-board fantasy. Behind it lie test flights of its prototype, his XB-35, and that bomber's jet-driven sister, the YB-49. It would differ from them mainly in having passenger cabins where they are rigged to carry bombs. Like the bombers, the air liner would have no tail. Trailing edges of the wing would serve as combination elevators and ailerons. Vertical air separators would increase directional stability.

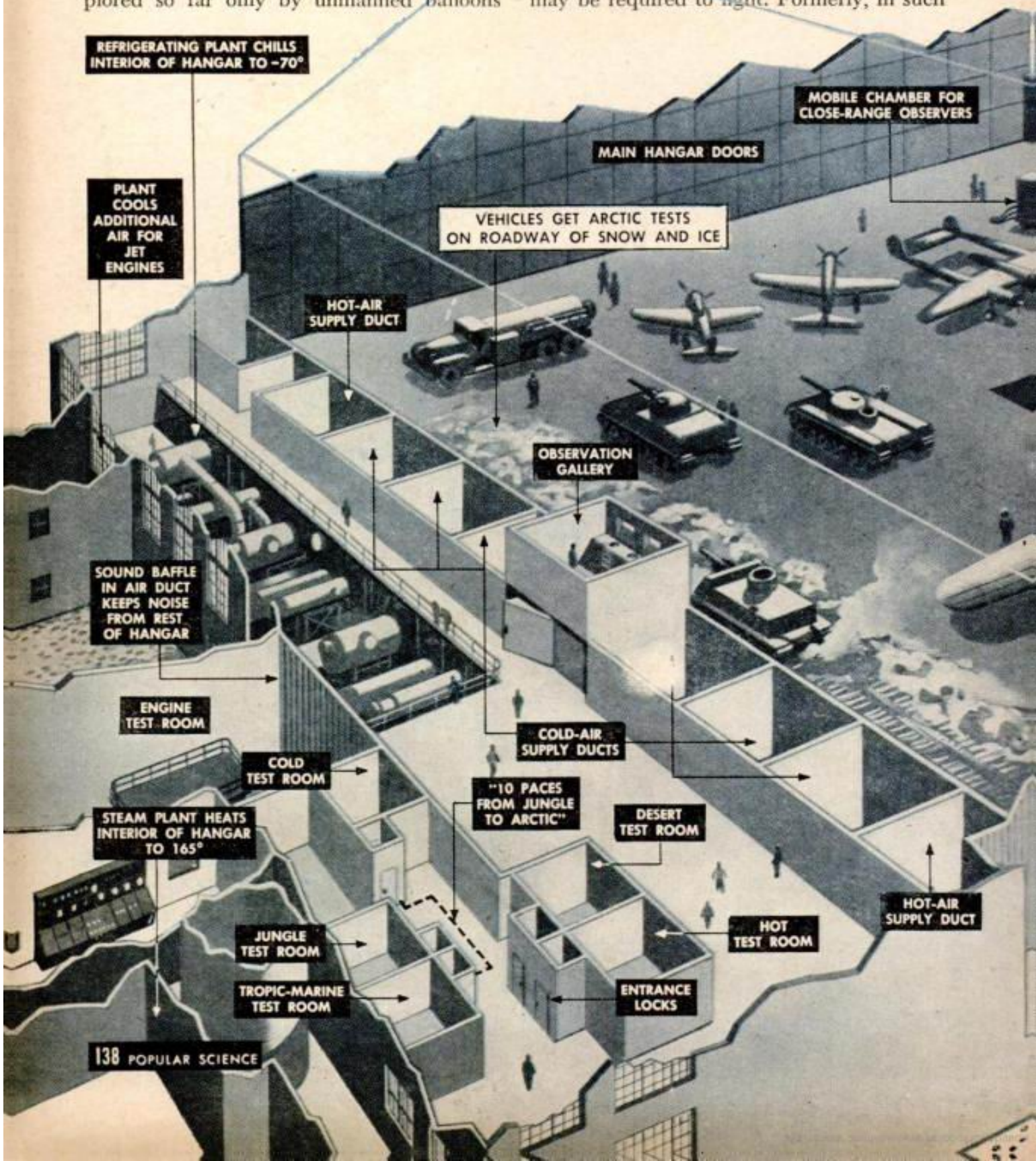
The flying-wing liner could be driven by jet engines—as shown here—or propellers.

All the World's Weather

IT TAKES exactly 10 paces to travel from the jungle to the Arctic in the Army Air Forces' new Climatic Hangar at Eglin Field, Florida. A few steps more transport you to the dry heat of the Sahara, to the salt-laden sea air of New Guinea, or to regions explored so far only by unmanned balloons

and rockets, 100,000 feet above the earth.

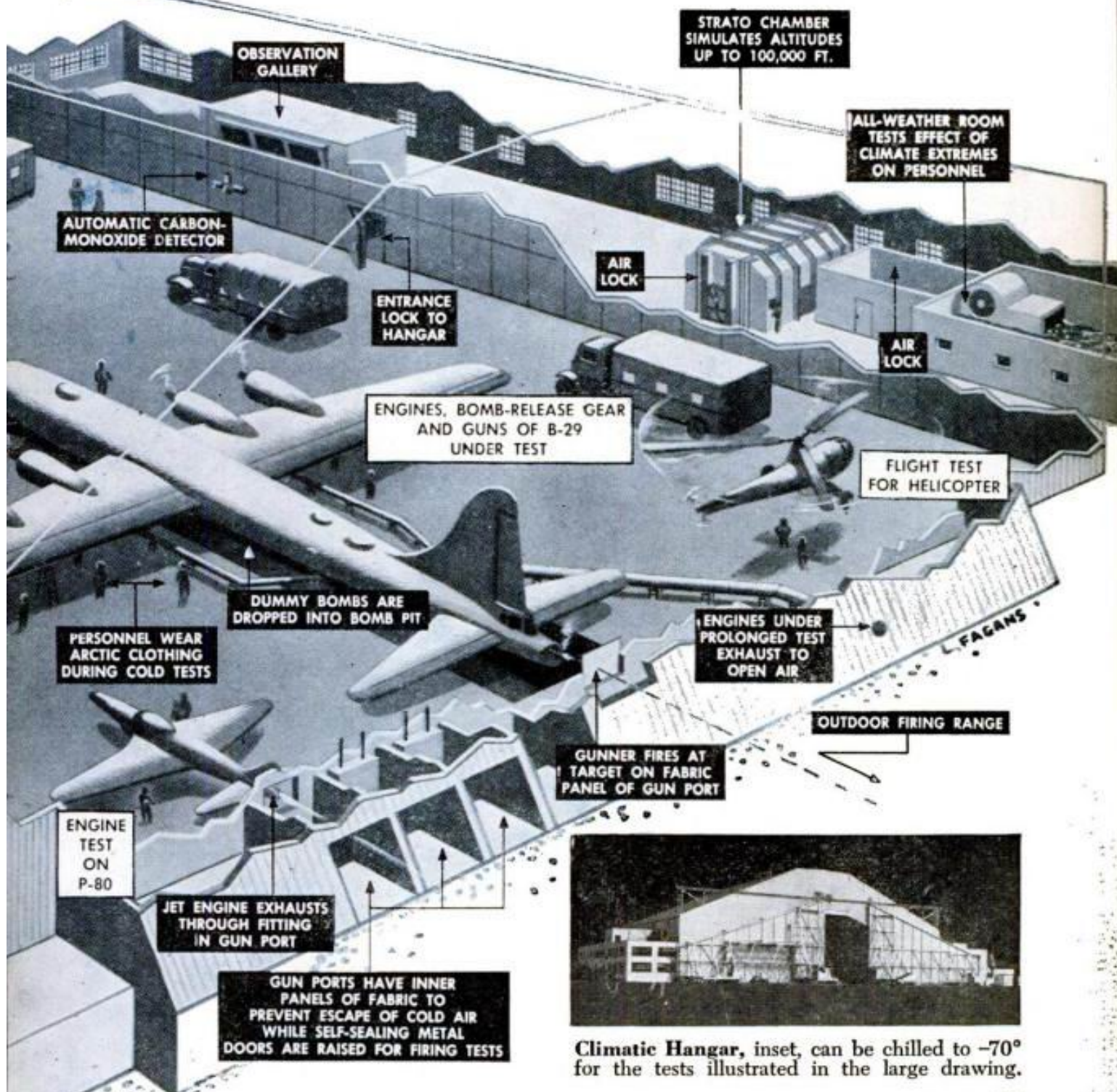
By providing all the world's weather under one roof, the Climatic Hangar enables the Air Proving Ground Command to determine the performance of men and machines anywhere upon the earth that they may be required to fight. Formerly, in such



Packed Under One Roof

elaborate and picturesquely named maneuvers as Operation Frigid, Operation Williwaw and Operation Furnace, expeditions have had to travel thousands of miles to try out Arctic and tropical gear—taking the fickle weather as they found it, or waiting another year. Now the Army's latest

weapons and tactics can be tested, improved, retested and OK'd at the accelerating tempo that preparations for tomorrow's style of warfare demand. Heading the program are guided missiles, gun turrets, bomb-release gear, storage batteries and lubricants suited to the newly important polar regions, 



Climatic Hangar, inset, can be chilled to -70° for the tests illustrated in the large drawing.

ships were at war's end, they nevertheless had:

1. Sunk twice as many Jap cargo vessels as all other American forces.
2. Sunk half as many Jap combat vessels as all other American forces.
3. Landed raiders on enemy islands, bombarded these islands, and recovered the raiders.
4. Rescued more than 500 American aviators from the sea.
5. Laid mines, carried fuel to beleaguered positions when surface ships could not, and performed outstanding feats of reconnaissance.
6. Destroyed 275,000 enemy lives, nearly as many as the entire American Army lost.

All that got the Navy to thinking. If a mutant vessel like the submarine—never recognized as being good for much besides stalking targets of opportunity—could accomplish such varied tasks with such great success, what might not a fleet of undersea craft, broken down into more specialized types to perform specific tasks, do?

The new submarines, by and large, will be about the same size and weight as World War II subs. They can be produced quickly and still incorporate the latest technological advances. This will be the sub-

marine of "tomorrow," not "day after tomorrow," but still built for the first time as a submarine from the keel up, not merely as a surface vessel that can submerge when it becomes necessary.

All the new types will have high speed and long range while submerged, on the principle that, from now on, the surfaced ship is the vulnerable ship. Speed will be limited only by power-plant developments, with atom power the ultimate objective. Range will be governed almost entirely by physical limitations of personnel. These limitations will depend on ability of engineers to provide continually improving air-revitalization systems. The food problem is being solved by development of concentrated foods that will keep crew members well above subsistence levels for long periods, without heavily burdening the submarine with supplies.

The speed factor will be increased by streamlining wherever possible. This streamlining is being accomplished by dispensing with deck armament and other external impedimenta, even by reduction of torpedo capacity and internal load.

The six types of submarines now visualized as components of an Atom Age fleet, along with specifications and missions, are:

DECK-RECESSED SCHNORKEL TUBE TO BE USED ONLY IN EMERGENCY FOR AIR

MESS HALL

BOW FLANE

COOL ROOM

REFRIGERATOR

BALLAST TANK FORWARD (with oxygen tank for air regeneration)

Attack Type

Speed: 26 knots submerged, or highest possible for quick strike and withdrawal.

Size: Present submarine size (1,800 tons, 310 feet long) or perhaps slightly smaller for higher maneuverability.

Shape: Ultimate in streamlining, for speed and maneuverability.

Range: As new power plants emerge, range will be limited only by physical limitations of personnel. Present goal, 25,000 miles.

Armament: None topside, all sacrificed for speed. Twelve high-speed, turbo-jet torpedoes with "on-and-off cam" device.

Special Characteristics: No torpedo tubes aft, to enhance streamlining; four tubes forward. Projectable radar antennas that can be raised and lowered while submerged.

Purpose: Destroy enemy sea power and commerce.

Comment: Cam devices on torpedoes cause them, at desired distance from firing point, to "patrol" back and forth, in effect setting up a torpedo screen against enemy vessels.

Reconnaissance & Picket Type

Speed: 15 knots submerged—little more than half that of ATTACK type.

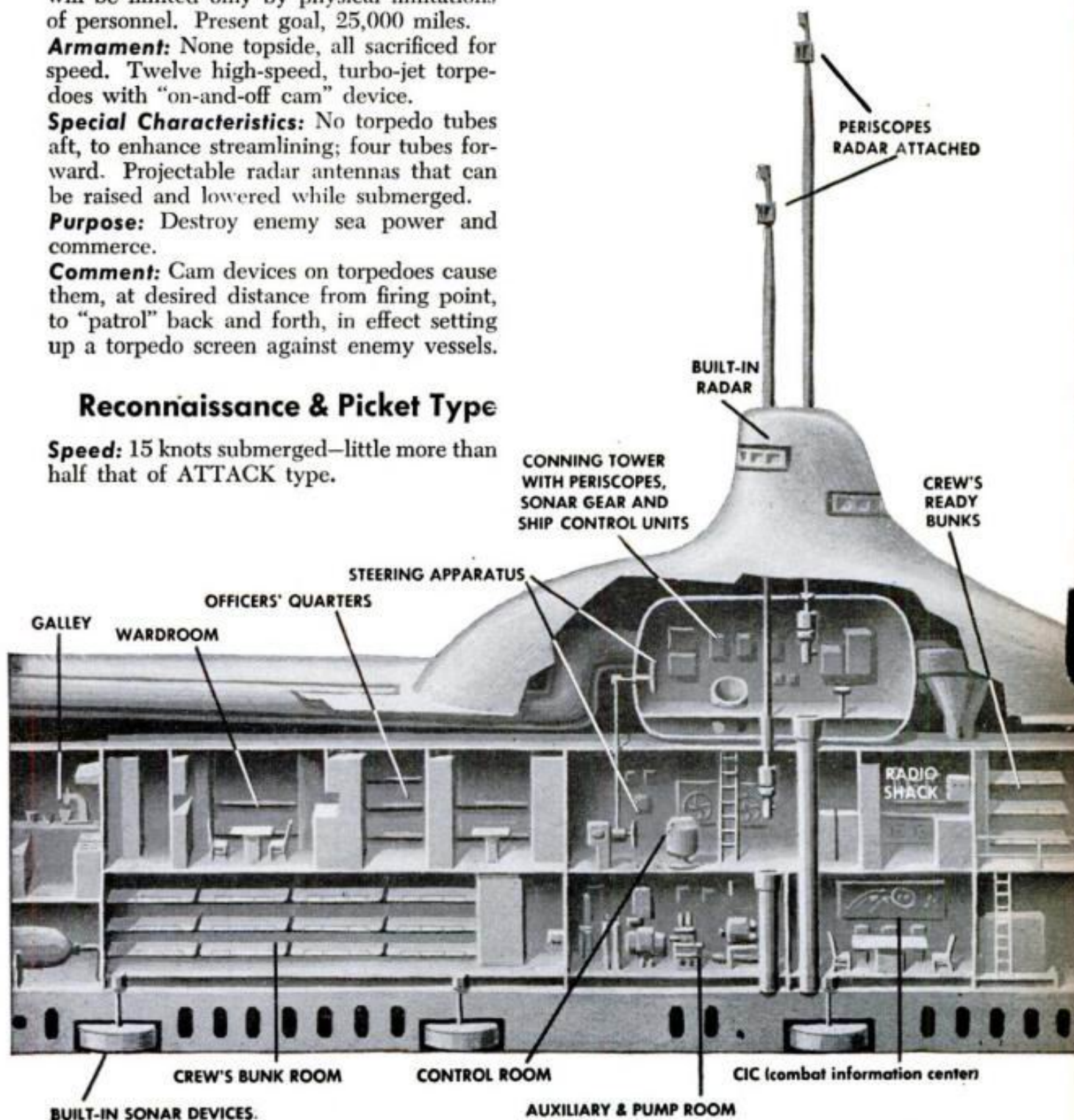
Size: Present size or smaller.

Shape: Streamlining commensurate with special purpose.

Range: As above.

Armament: None.

Special Characteristics: Room for variety of radar, including long-range, aircraft, surface search. All radar antennas retractable for submerged operation. Good periscope



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photographic facilities. Good communications facilities, also with retractable antennas for operation while submerged.

Purpose: Patrol and spotting, origination of radio reports on enemy dispositions and installations to American attack forces. May work in team with ATTACK and AIRCRAFT-CARRIER types.

Comment: On this and other types, all antennas must be retractable for underwater operation to preclude great danger of detection by enemy radar when surfaced. To contain all necessary radar and communications equipment, this type must make a sacrifice in streamlining and therefore in speed. Speed loss can be accepted, because primary function of recco sub is to remain in danger areas indefinitely and report vital information.

Transport Type

Speed: 15 knots submerged.

Size: Three times that of present subs, or about 6,000 tons.

Shape: As with the transport aircraft, as opposed to the military aircraft, streamlining is sharply reduced to permit increased carrying capacity.

Range: As above.

Armament: Large rocket launchers and anti-aircraft guns on deck for defense against

enemy attack and before-landing barrages.

Purpose: Landing of troops for commando, espionage and other behind-the-lines activities and for evacuation of personnel.

Comment: About 600 equipped, special-purpose troops can be carried. Submarines transported as many as 300 Marines per unit in World War II.

Cargo Type

This type will differ from TRANSPORT type only in compartmentation and purpose. It would be built for adaptation either as a dry-stores carrier or a liquids carrier. It would be used to deliver supplies to besieged garrisons or critical war-production materials to allied powers. Might work in team with TRANSPORT type in following up attack landings with supplies.

Aircraft-Carrier Type

Speed: 15 knots submerged. Higher speed desirable but impractical under load factor.

Size: 6,000 tons.

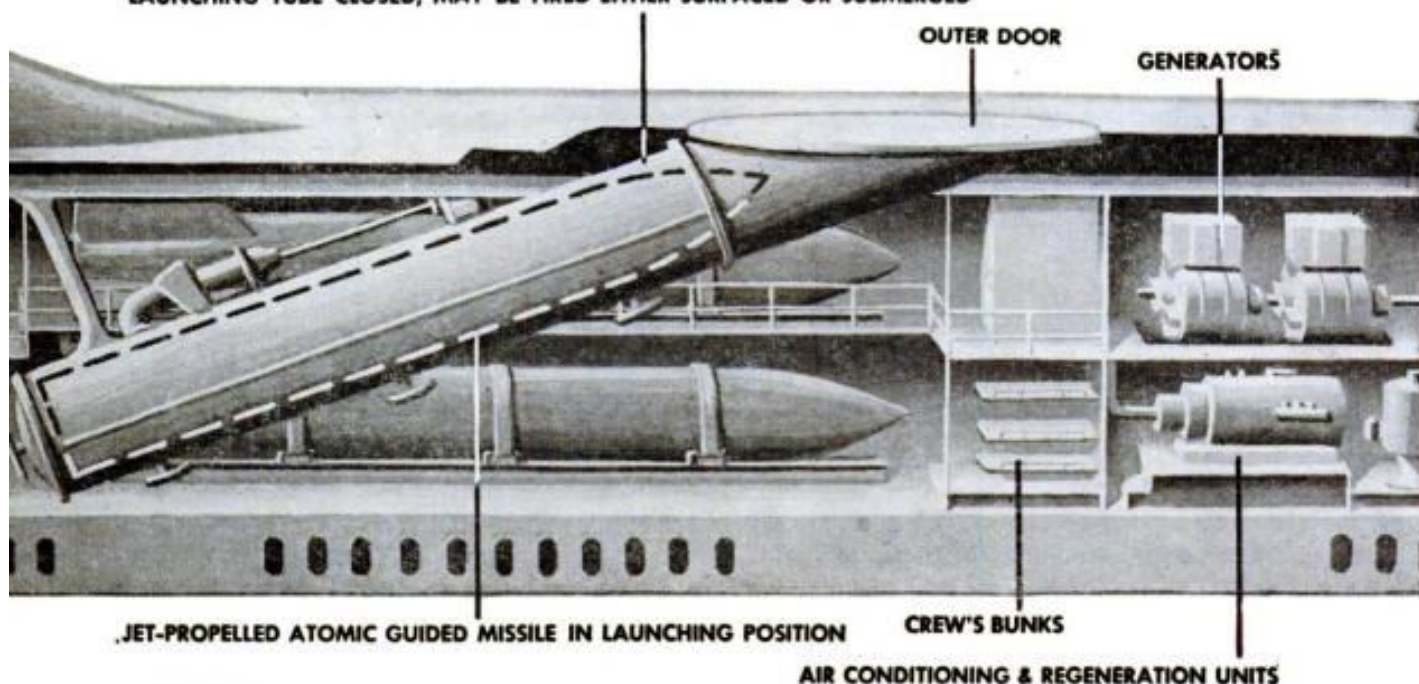
Shape: Bulky.

Range: As above.

Armament: Deck AA guns.

Special Characteristics: Hangar space, aircraft maintenance facilities, plane catapult, radar, good communications facilities, ca-

LAUNCHING TUBE CLOSED; MAY BE FIRED EITHER SURFACED OR SUBMERGED



capacity to carry the fuel required by aircraft.

Purpose: Extension of scouting range beyond that of recco sub. Aircraft scouts could fly well beyond recco's radar range and report back by radio on enemy naval groupings. Secondary purpose, dropping of atomic bombs.

Comment: Bombing value of sub-borne aircraft is depreciated by planners, who foresee development of guided missiles with longer range and greater accuracy. Also low-rated is the possibility of pilot survival and recovery; hence, even scouting missions over land installations, which can usually be more heavily defended than sea forces, are ruled out except in unusual situations. The Japanese at the end of the war had several of the 3,000-ton I-14 class, which carried two planes each, and a couple of the 5,000-ton I-400 class, each of which carried four planes. Each plane could carry only one 1,500-pound bomb. Planners agree that this is not an economical manner in which to mount an effective aerial bombardment force and fail to see the plane-toting pigboat as a successor to the surface aircraft carrier.

Guided-Missile Type

Speed: 24 knots submerged, or highest speed possible to evade coast defenses.

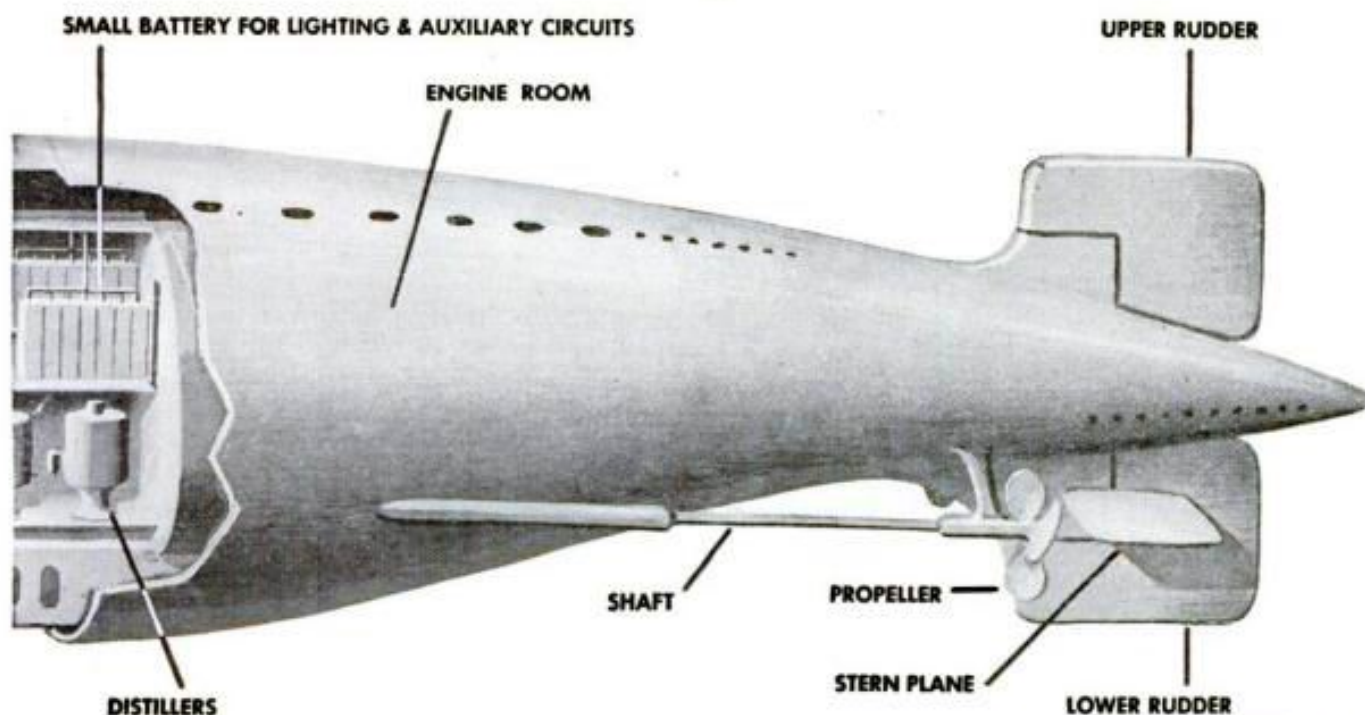
Size: Slightly larger than present sub-



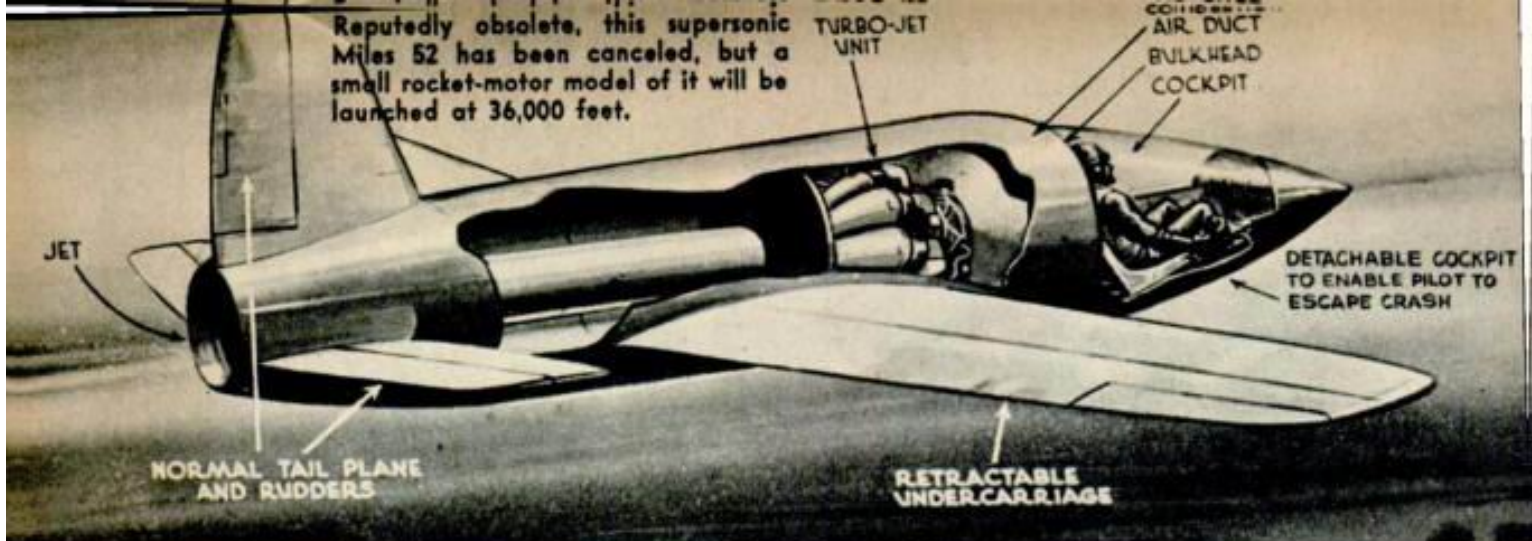
This Type 21 German submarine shows the Nazis' advanced streamlining. All unnecessary gear has been stripped from her deck. Even the guns are gone.



Two captured Type 21s. Schnorkel—breather tube—and elaborate periscopes and radio antennas are extended on sub at right, retracted on craft at left.



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Britain Goes Supersonic

Engineers race to design first plane to fly faster than sound.

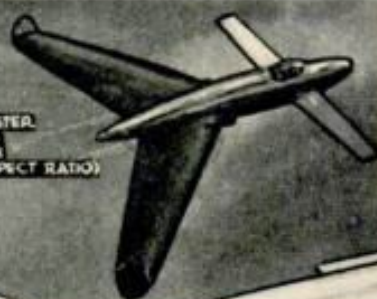
B RITISH engineers are making an all-out attempt to build aircraft that fly faster than the speed of sound. To do it they are concentrating on developing gas turbines, jet propulsion and rocket engines.

British airplanes have broken existing world speed records in recent months. Now British experts are developing engines and planes to set fresh marks. Hint of what they are like is given by the canceled Miles 52, apparently obsolete even before completion. The M-52's 17,000-hp. three-stage power plant almost filled the fuselage. Ex-

haust from a jet engine with centrifugal blower ran a gas turbine. This brought more air into the stream and pushed it into a duct. Here more fuel was burned to give an extra push. The plane was expected to hit 1,000 m.p.h., 250 m.p.h. faster than sound. The ones under wraps presumably are planned to do even better.

The solution of supersonic difficulties is complicated by the fact that ordinary wind tunnels cannot be used for testing. Air bounding off the sides sets up disrupting currents, and a shock wave "chokes" the tunnel. For this reason British engineers are using various types of pilotless models, some dropped from high altitudes, some depending on rockets.

THE "FLYING DUCK" TYPE
AN AIRCRAFT DESIGNED TO FLY FASTER THAN THE SPEED OF SOUND, HAVING REAR WINGS WITH LARGER SPAN THAN CHORD (I.E. HAVING LARGE ASPECT RATIO)



Various designs proposed for supersonic aircraft. The swept-back wings and delta designs are intended to cut drag but offer control difficulties if used at low speeds.

SHARP-POINTED FUSELAGE

FRONT WINGS WITH ONLY SHORT SPAN AND LARGE CHORD (LOW ASPECT RATIO)

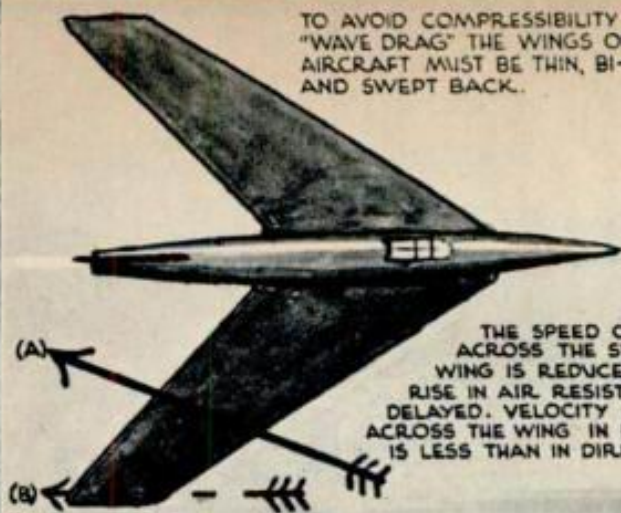
POSSIBLY THE TWO WINGS MAY BE CONVENIENTLY COMBINED INTO THIS TRIANGULAR "DELTA" DESIGN

CHORD

SPAN OF WING

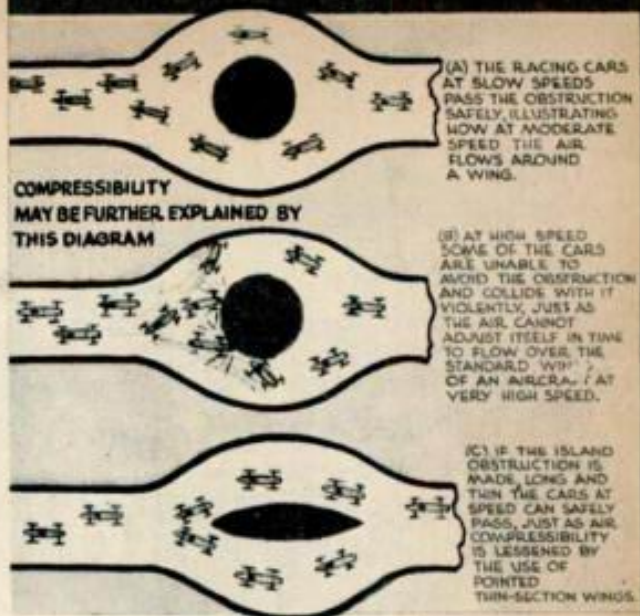
A GERMAN "DELTA" PROJECT BY DR. LIPPICH

TO AVOID COMPRESSIBILITY AND REDUCE "WAVE DRAG" THE WINGS OF SUPER-SONIC AIRCRAFT MUST BE THIN, BI-CONVEX AND SWEEP BACK.



THE SPEED OF AIR-FLOW ACROSS THE SWEEP-BACK WING IS REDUCED AND THE RISE IN AIR RESISTANCE DELAYED. VELOCITY OF AIR ACROSS THE WING IN DIRECTION (A) IS LESS THAN IN DIRECTION (B)

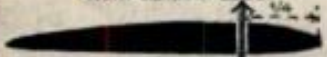
COMPRESSIBILITY MAY BE FURTHER EXPLAINED BY THIS DIAGRAM



SUPER-SONIC

SUB-SONIC

AT SUB-SONIC SPEEDS THE LIFT OF A WING IS AT A POINT IN BACK FROM LEADING EDGE.



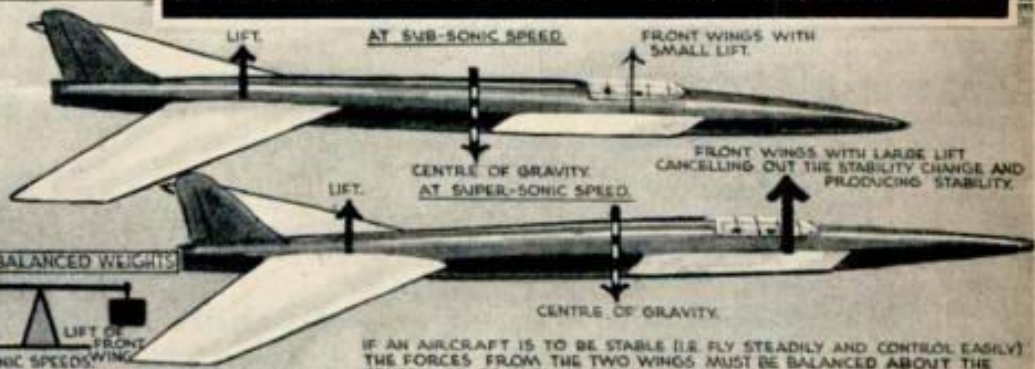
AT SUPER-SONIC SPEED THE STABILITY CHANGE OCCURS AND THE LIFT MOVES REARWARD TO 1/2 WAY BACK.



THE STABILITY CHANGE ILLUSTRATED BY BALANCED WEIGHTS

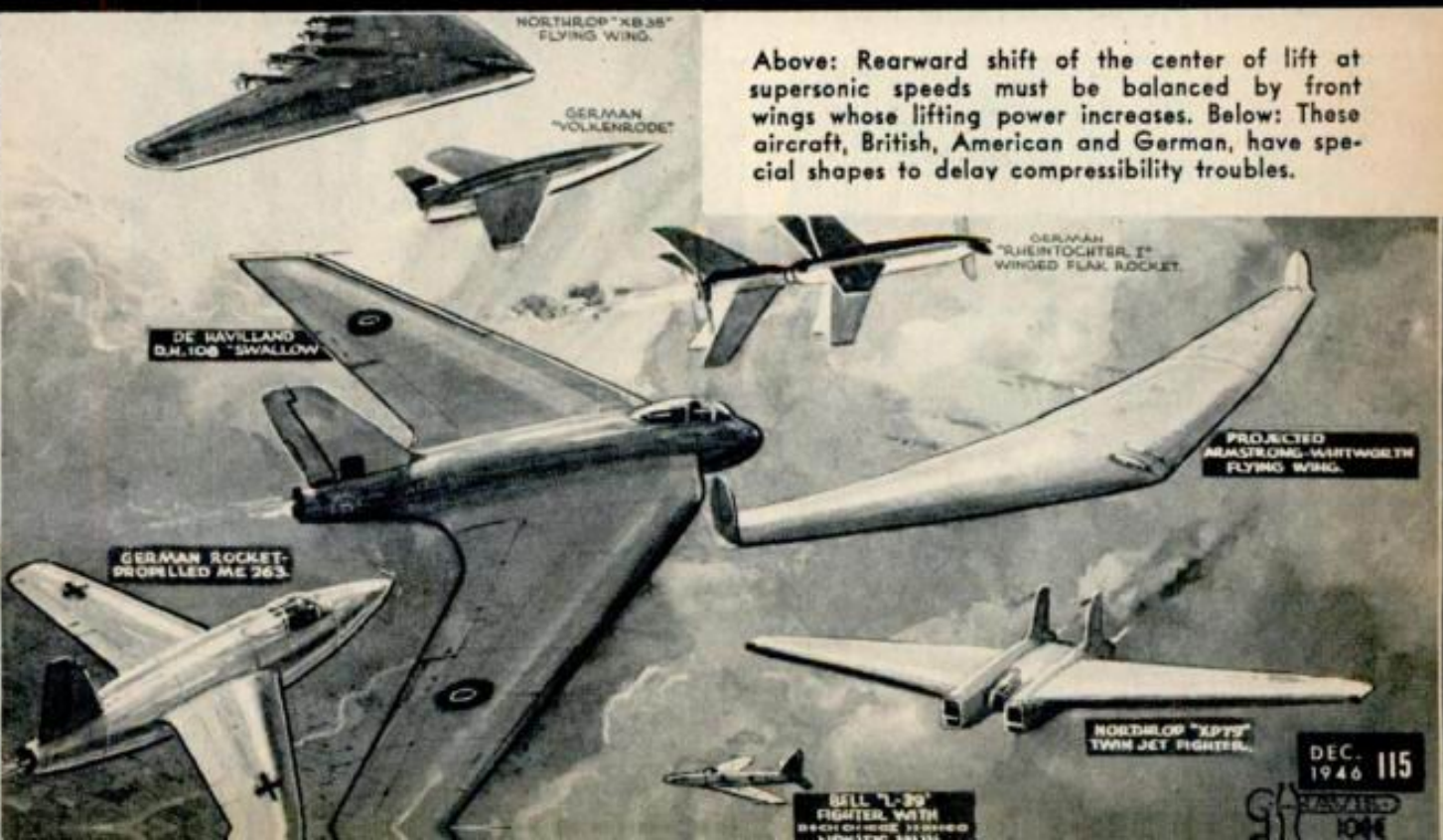


"STABILITY CHANGE" ASSOCIATED WITH FLIGHT THROUGH THE SPEED OF SOUND



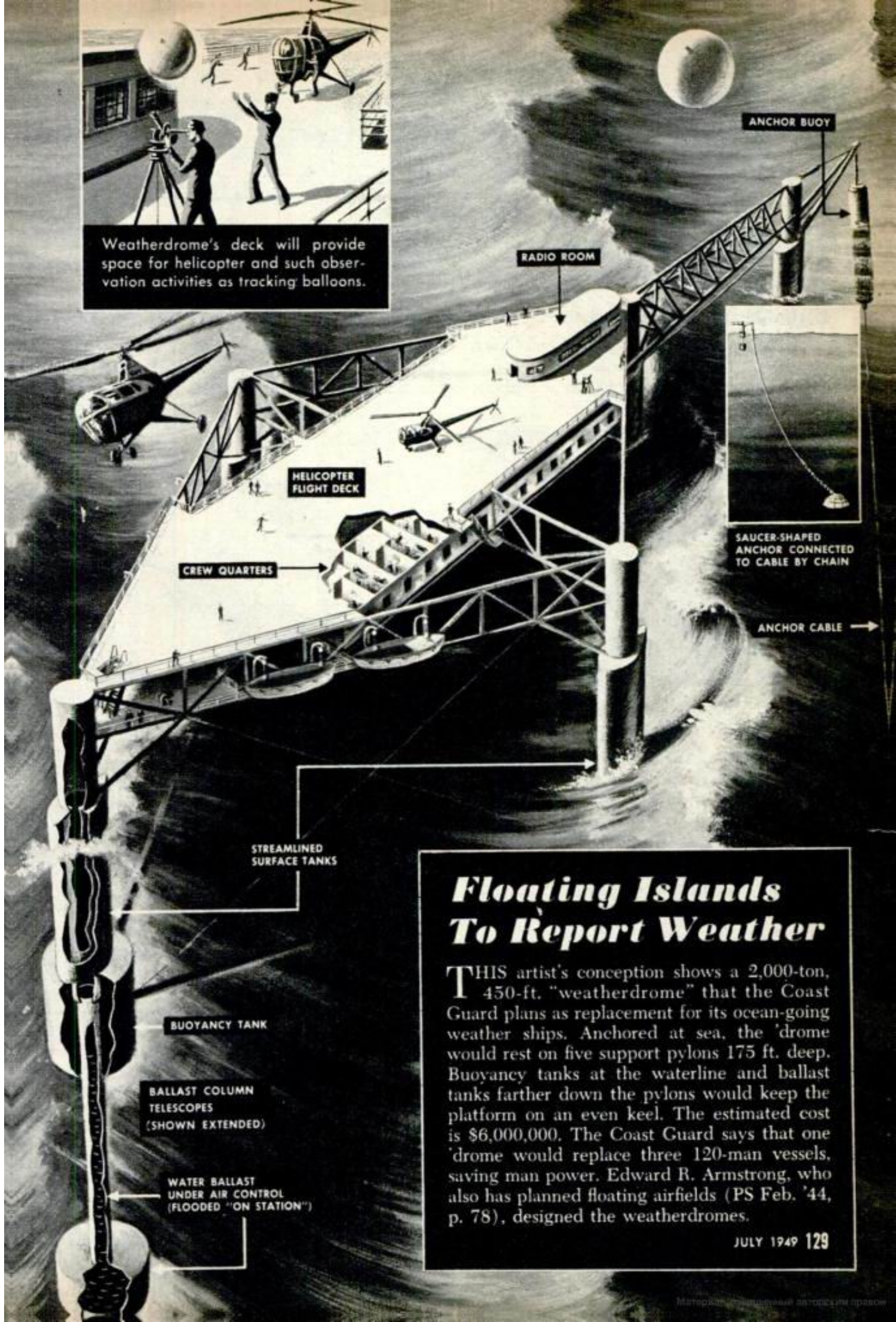
IF AN AIRCRAFT IS TO BE STABLE (I.E. FLY STEADILY AND CONTROL EASILY) THE FORCES FROM THE TWO WINGS MUST BE BALANCED ABOUT THE CENTRE OF GRAVITY OF THE AEROPLANE.

Above: Rearward shift of the center of lift at supersonic speeds must be balanced by front wings whose lifting power increases. Below: These aircraft, British, American and German, have special shapes to delay compressibility troubles.





Weatherdrome's deck will provide space for helicopter and such observation activities as tracking balloons.



RADIO ROOM

ANCHOR BUOY

HELICOPTER
FLIGHT DECK

CREW QUARTERS

SAUCER-SHAPED
ANCHOR CONNECTED
TO CABLE BY CHAIN

ANCHOR CABLE

STREAMLINED
SURFACE TANKS

BUOYANCY TANK

BALLAST COLUMN
TELESCOPES
(SHOWN EXTENDED)

WATER BALLAST
UNDER AIR CONTROL
(FLOODED "ON STATION")

Floating Islands To Report Weather

THIS artist's conception shows a 2,000-ton, 450-ft. "weatherdrome" that the Coast Guard plans as replacement for its ocean-going weather ships. Anchored at sea, the 'drome would rest on five support pylons 175 ft. deep. Buoyancy tanks at the waterline and ballast tanks farther down the pylons would keep the platform on an even keel. The estimated cost is \$6,000,000. The Coast Guard says that one 'drome would replace three 120-man vessels, saving man power. Edward R. Armstrong, who also has planned floating airfields (PS Feb. '44, p. 78), designed the weatherdromes.

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The Constitution shelters a prewar eight-passenger transport under its 189-ft. wing.



FLYING DUPLEX

NAVY'S TWO-DECK TRANSPORT
CARRIES 180 PERSONS,
FLIES 6,000 MILES.

THE WORLD'S largest land-based transport plane, the Lockheed Constitution, big enough to carry 180 people or 35 tons of cargo 6,000 miles at top speed of 300 m.p.h., will take off on its first flight this month from the factory's field at Burbank, Calif. Designed to meet the Navy's need for a huge plane capable of reaching any island outpost with high-priority loads of men and equipment, the 92-ton Constitution is expected to be making one-stop flights from the West Coast to Japan and China within a year. It will find its way with the most complete navigational radar equipment ever installed in aircraft.

Now equipped with four 3,000-hp. Pratt & Whitney Wasp Major engines, the 156-foot airplane has characteristics that promise even more speed and power. Its high-altitude, high-speed, laminar-flow wing will permit the installation of gas turbines when they become available.

Within its figure-eight, "double bubble" fuselage, the Constitution can carry 92 pas-

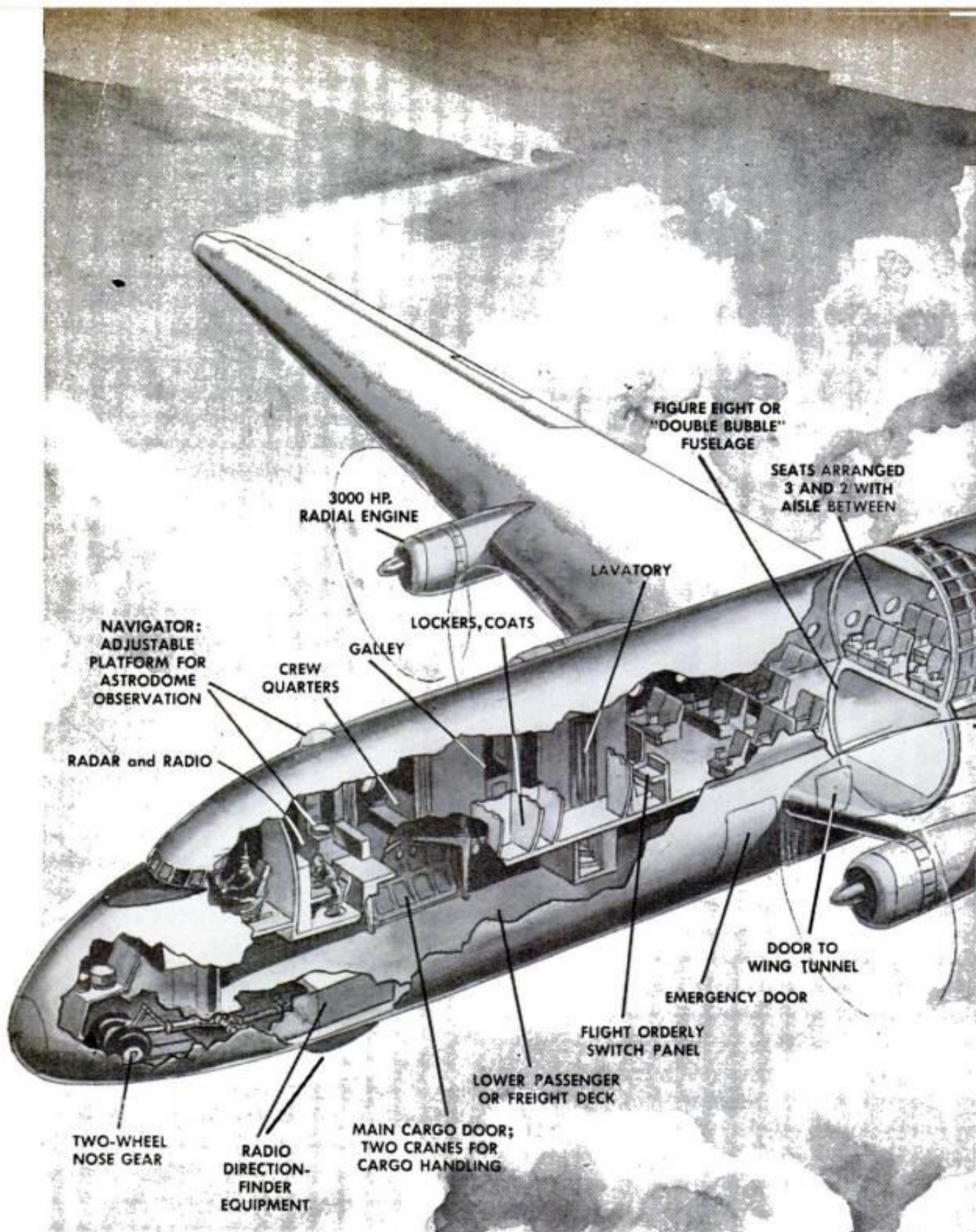
sengers on an upper deck and 76 on a lower, in addition to a crew of 12. Spiral stairways fore and aft connect the decks.

The entire lower deck may be used for cargo. Hoists that can lift five tons at a crack will load and unload the plane at isolated bases through wide doors (106 by 74 inches) in the fuselage.

Two Constitutions have actually been built, at a total cost of \$27,000,000. One will fly while the other undergoes extensive static tests to measure its full strength and potentialities accurately.

While it is estimated that the Constitution, because of its great weight, can operate from only 50 airstrips in the world, it can take off fully loaded in 2,350 feet, land over a 50-foot obstacle and grind to a stop in 2,300 feet. This equals the performance of many smaller transports. On small island fields, reversible inboard props will shorten the landing distance somewhat.

Four wheels on each main gear provide enough footprint area for landings on rough

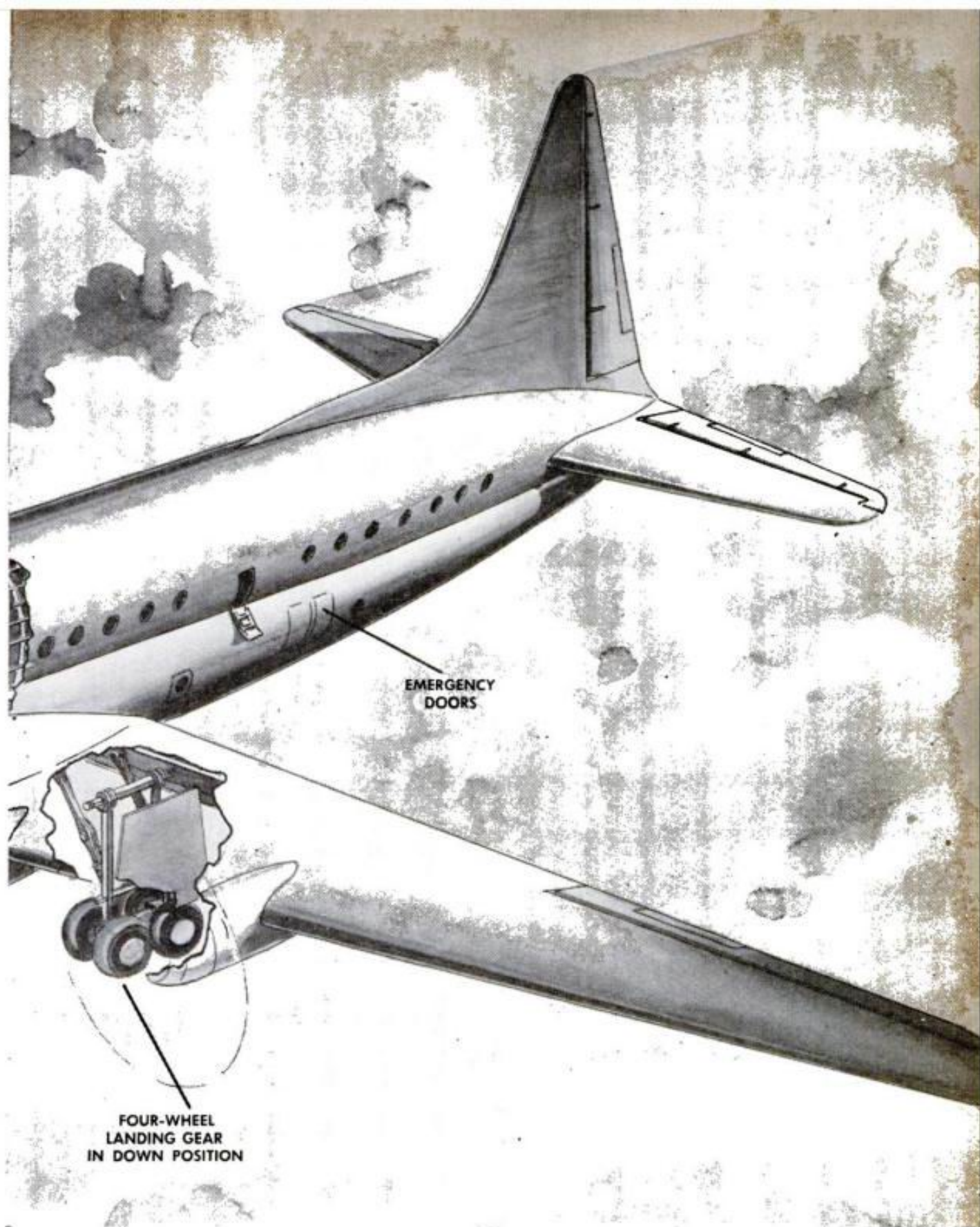


tropical airstrips, and save a ton of structural weight. The plane also lands without the smoking impact usual with big planes: pre-rotation devices turn the wheels at landing speed just before they touch the earth.

For safety, the flight engineer will observe all propellers from his station through wide-angle lenses fitted into the side walls. He can reach all engines and most of the fittings

through man-sized tunnels in the wing if he wants to make inspections or repairs in flight. A one-shot lubrication system makes it possible to pump oil to all four nacelles.

Air bled from the engine turbos and heated to 300 degrees F. keeps all leading edges warm enough to prevent the formation of ice, while electric wires imbedded in the windshields guarantee unobstructed views for the



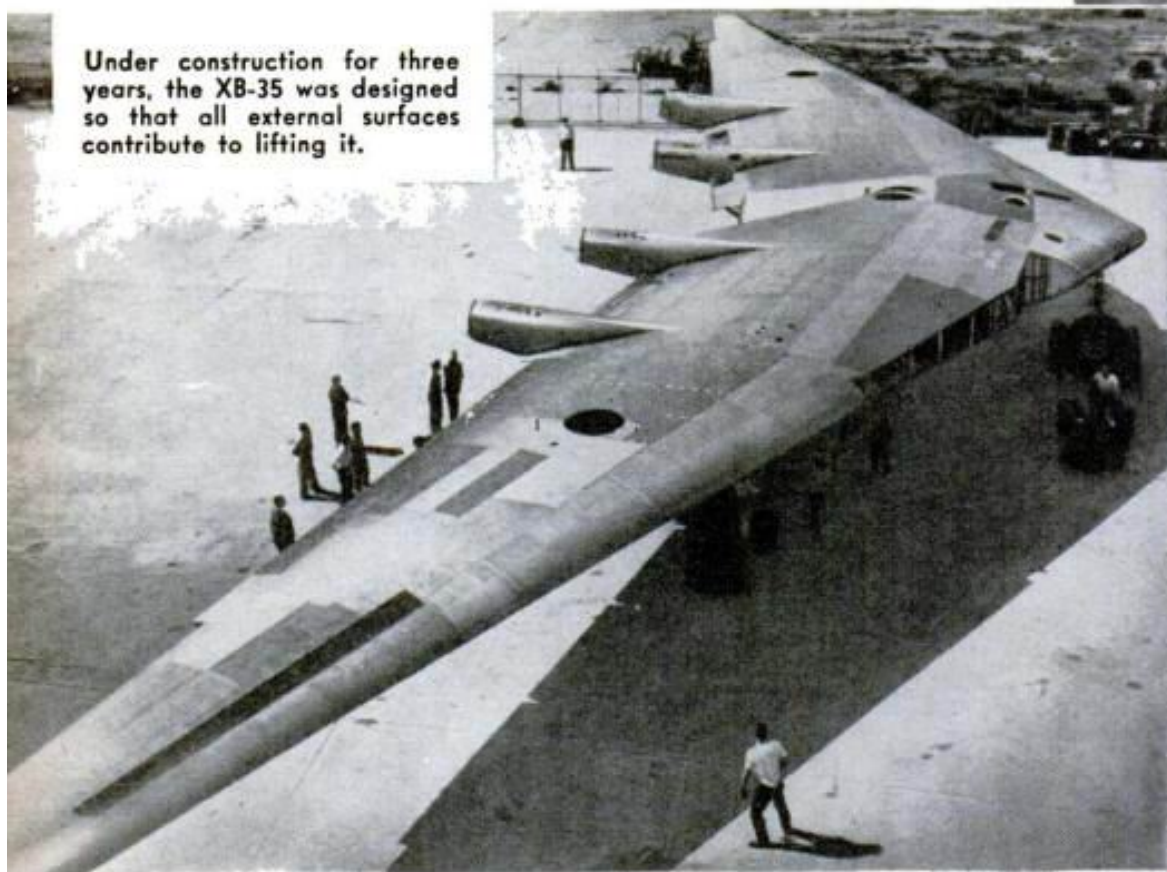
pilots. Some of the edge-heating air (PSM, July '46, p. 112), moving through a pair of heat exchangers, warms the cabin.

Three hundred hot meals can be served aboard on long flights. Immersion heaters in tanks by the stairwell and under the wash basins in the rest room provide hot water for cooking, bathing and shaving. Garbage, stowed in tin cans, will be tossed overboard

when the plane is flying at low altitudes over open ocean.

Enough gasoline to fly 6,000 miles—9,990 gallons—is carried in four integral wing tanks, sealed tight with putty made from crude rubber. So fueled, the Constellation can ferry important cargoes from New York to the Panama Canal in eight hours, to Dakar in West Africa in 13 hours.

Under construction for three years, the XB-35 was designed so that all external surfaces contribute to lifting it.



100-Ton flying wing

OUTSTRIPS B-29

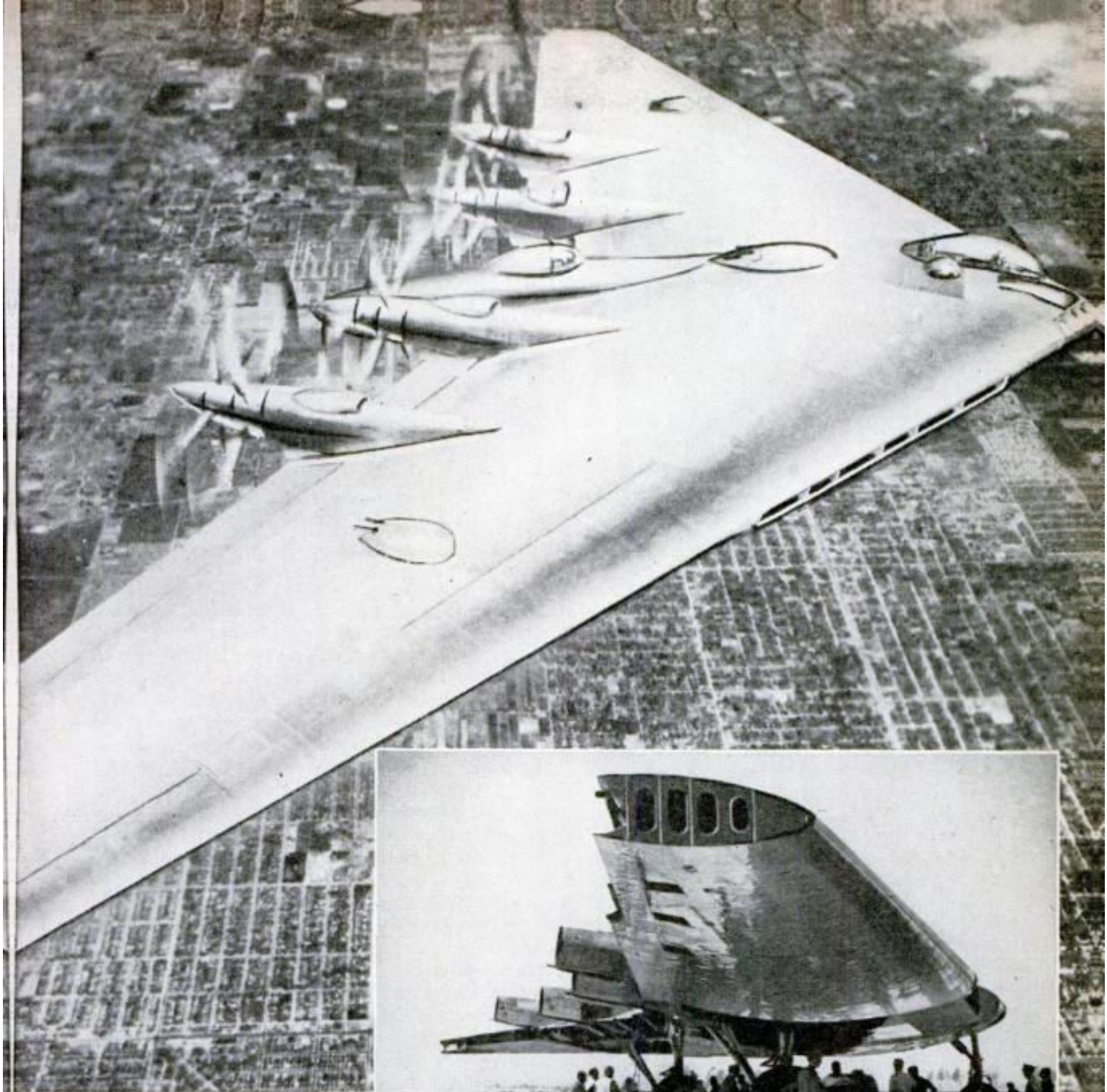
By **LEON SHLOSS** and
ANDREW R. BOONE

EFFORTS to make tailless aircraft practical began the year before Orville Wright was born. At least 40 pioneers, of nearly as many nationalities, have contributed to the science. Now an American, John K. Northrop, has done it with the Army's XB-35 bomber.

This plane, weighing 89,000 pounds empty, under overload conditions will lift 60 tons of bombs, gas, crew and cargo. The 209,000-pound gross weight is 78,000 pounds more than that of the Boeing B-29 Superfortress. The boomerang-shaped wing is 4,000 square feet in area, more than double the B-29's; hence the great lifting power. Most parasite drag went out with the fuselage, and higher speed came in. The speed figure is

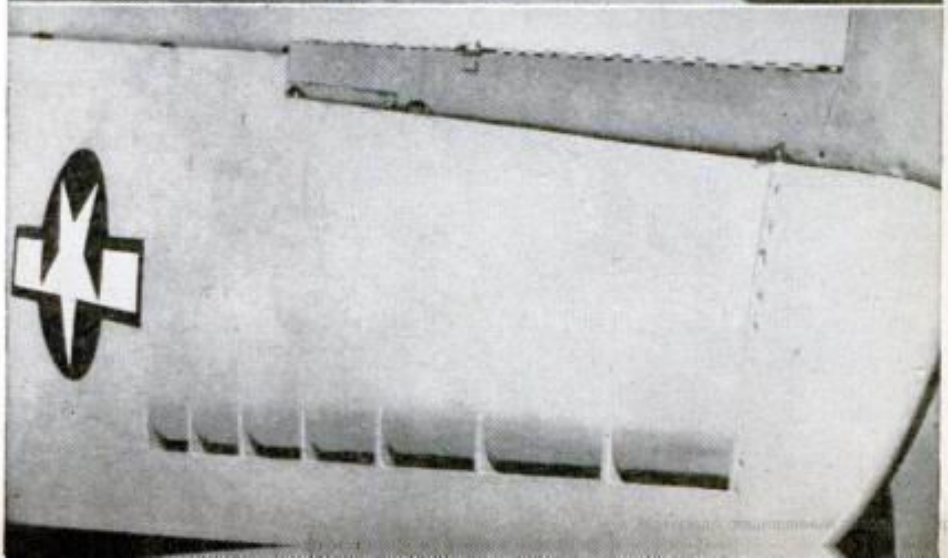
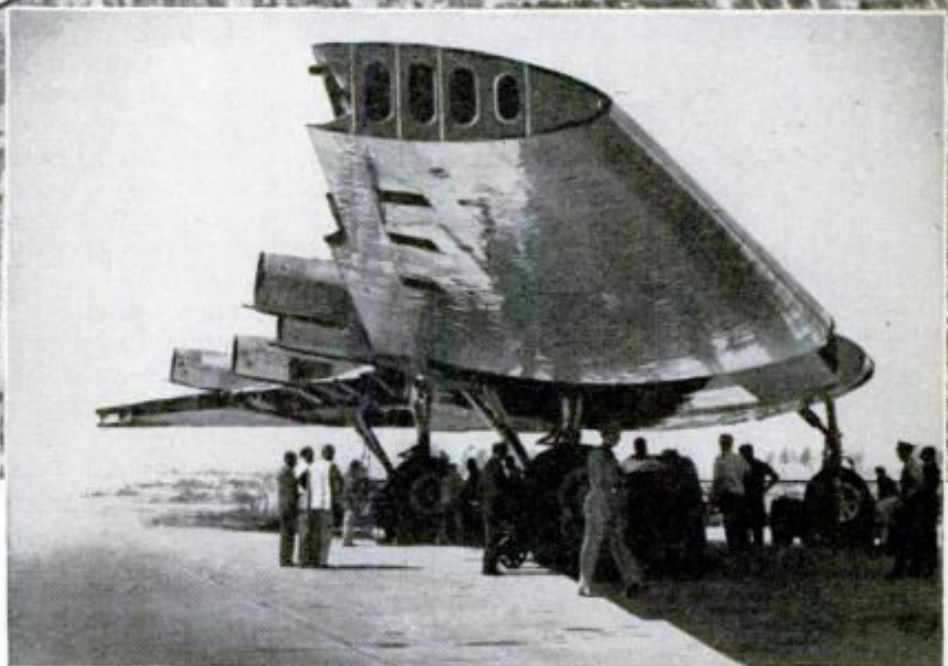
undisclosed, but it is known that the plane is expected to outfly the fastest conventional fighters, which approach 500 m.p.h. Four Pratt & Whitney 3,000-hp. engines turn Hamilton Standard coaxial pusher propellers. Fifteen Flying Wings have been ordered, with jet power in prospect for future models. The plane will be shown about the time this story appears. First flight depends on progress of pilots who are preparing to fly the radical giant. Complicating the problem was the death of the outstanding Flying Wing test pilot, and the short, 5,700-foot runway from which the first take-off must be made.

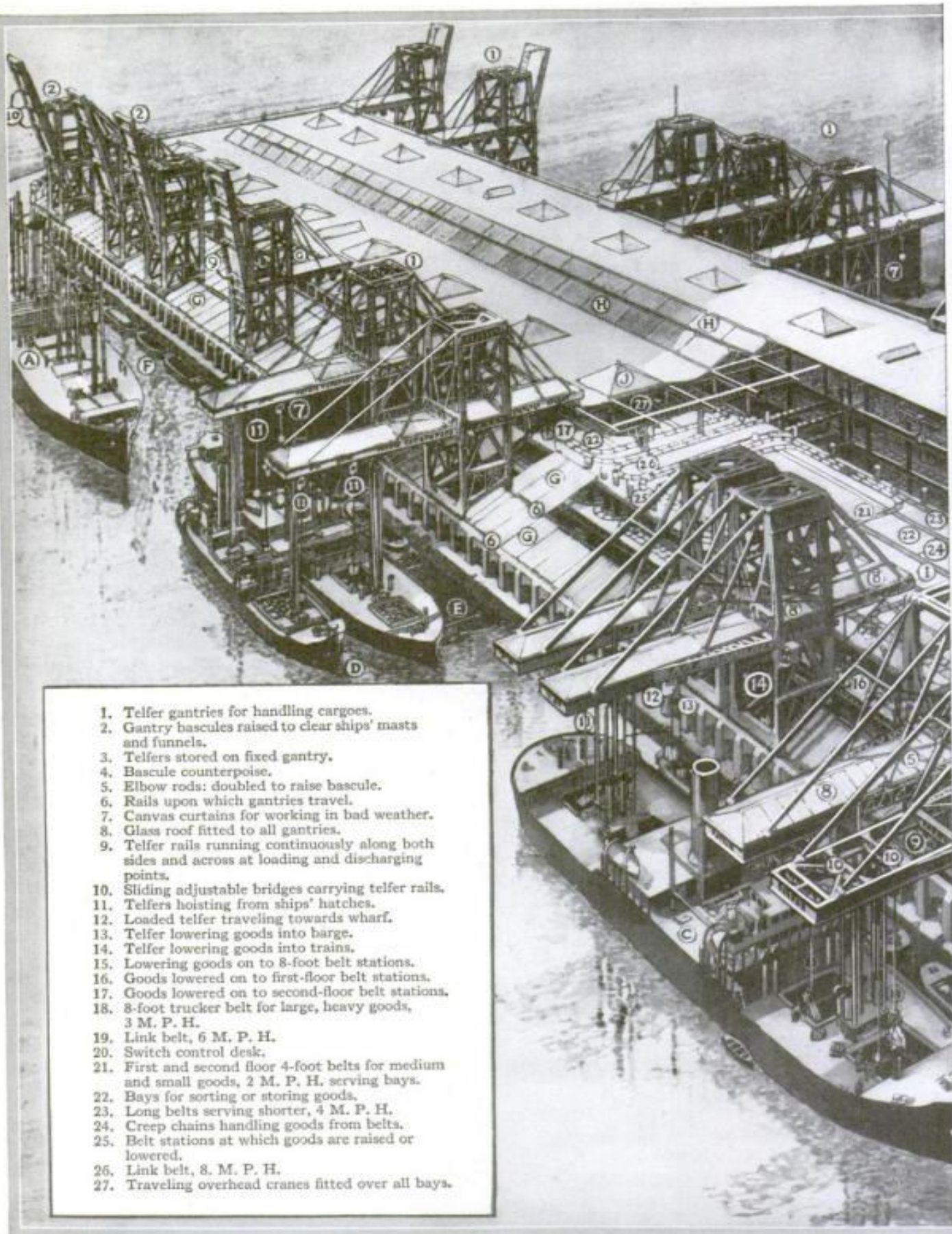
Built by the Northrop Aircraft Co., at



Artist's conception (above) shows XB-35 in flight over Los Angeles. To the right you see open section of wing that may hold cargo.

Wing slots on the N9M, 60-foot scale-model forerunner of the XB-35, were added to increase stability at low flying speeds. Control is achieved by slots, wing rudder and tabs, plus Northrop "elevons," which function as combined ailerons and elevators.



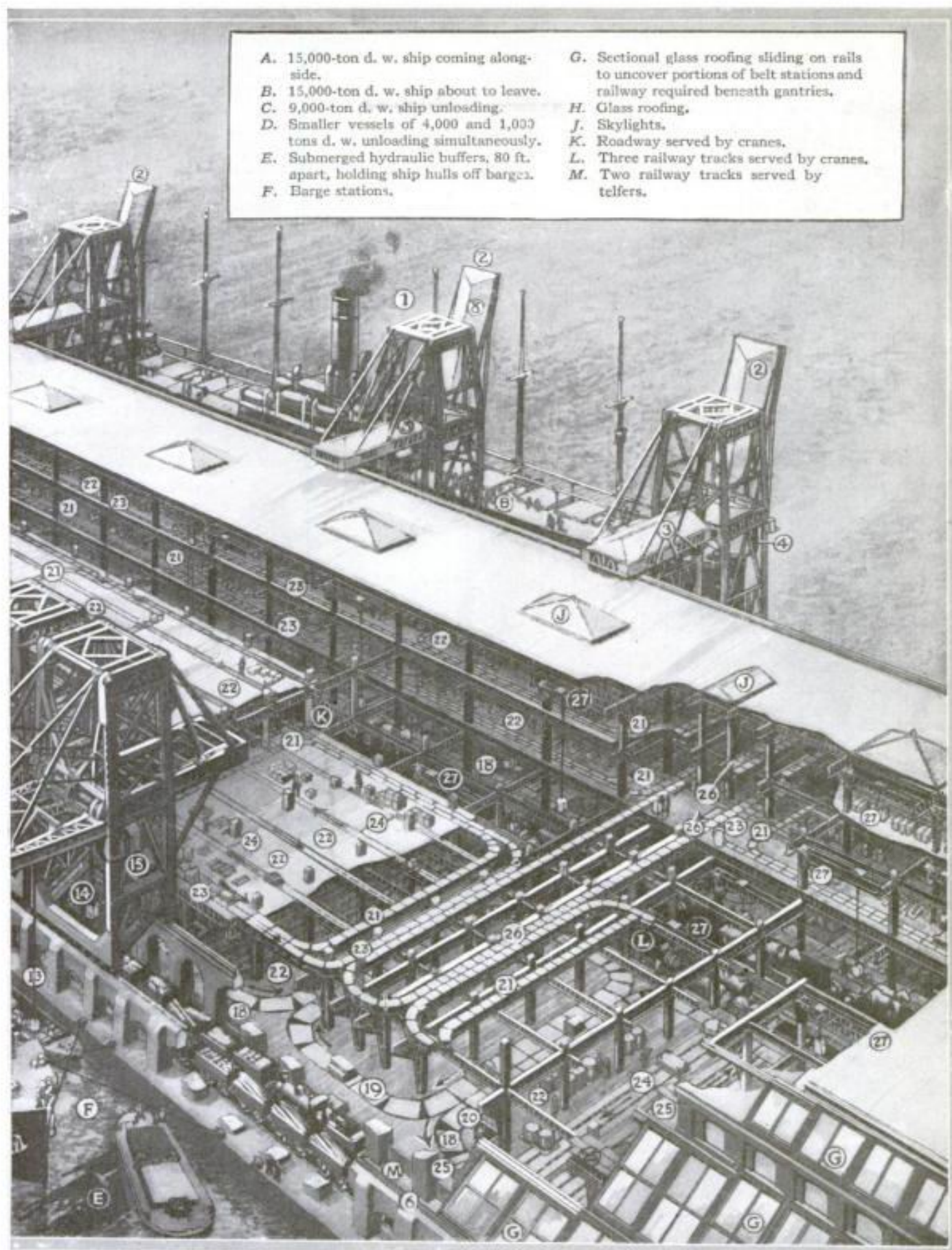


1. Telfer gantries for handling cargoes.
2. Gantry bascules raised to clear ships' masts and funnels.
3. Telfers stored on fixed gantry.
4. Bascule counterpoise.
5. Elbow rods: doubled to raise bascule.
6. Rails upon which gantries travel.
7. Canvas curtains for working in bad weather.
8. Glass roof fitted to all gantries.
9. Telfer rails running continuously along both sides and across at loading and discharging points.
10. Sliding adjustable bridges carrying telfer rails.
11. Telfers hoisting from ships' hatches.
12. Loaded telfer traveling towards wharf.
13. Telfer lowering goods into barge.
14. Telfer lowering goods into trains.
15. Lowering goods on to 8-foot belt stations.
16. Goods lowered on to first-floor belt stations.
17. Goods lowered on to second-floor belt stations.
18. 8-foot trucker belt for large, heavy goods, 3 M. P. H.
19. Link belt, 6 M. P. H.
20. Switch control desk.
21. First and second floor 4-foot belts for medium and small goods, 2 M. P. H. serving bays.
22. Bays for sorting or storing goods.
23. Long belts serving shorter, 4 M. P. H.
24. Creep chains handling goods from belts.
25. Belt stations at which goods are raised or lowered.
26. Link belt, 8 M. P. H.
27. Traveling overhead cranes fitted over all bays.

How A. S. Gattie, an English engineer, would reduce the high cost

It costs three thousand dollars a day to hold an ocean freighter in port to load or unload a cargo, and one thousand dollars a day to hold a coastwise or tramp steamer. We, the consumers, pay the bills in the end, and it's a big

bill when you consider what are the delays incurred in moving six hundred million tons across the marine freight terminals of our ports. What is the solution of the problem? An English engineer, A. S. Gattie, offers the Gattie



of living by loading and unloading ships with automatic machinery

system illustrated by the picture above: huge self-propelling cranes, railway tracks on which freight trains run, a system of automatic conveyers. A vessel berths; an empty freight train draws alongside; a crane handling

twelve tons a minute runs into position opposite one of the hatches. The cargo is hoisted and deposited into freight-cars or lighters, or upon belt conveyers, by which it is delivered to any desired bay in a storage warehouse

share of the increase which their own charges help to raise. The evil grows progressively, increasing like a rolling snowball, while the people wonder why the cost of living is ever increasing.

How Gattie Would Solve the Problem

One of the first to recognize and energetically urge the necessity for reforming this system on a drastic and comprehensive scale was an English engineer, Mr. A. S. Gattie, who for many years has been developing the plan pictured in the accompanying illustrations. Mr. Gattie's scheme, for convenience, may be considered under two headings. The first (a) involves the provision at all important ports of adequate apparatus for the loading and discharge of ships, and the erection of suitable buildings on the wharves, equipped with mechanical and automatic devices for the quick sorting, storing, and dispatch of freight. The second (b) involves the construction at every big railway center of a central freight clearing-house which is to take the place of the existing independent railway freight-yards, the building being equipped throughout with mechanical hoists and conveyers, by which freight may be rapidly transferred, sorted, and dispatched, connected by underground lines with all the principal railways and communicating by roadways with the consignee. Standardized containers (cases, crates, or slings) are to be used, in which the cargo or freight is to be held, so that it can be bodily transferred in bulk to and from freight-cars and motor-trucks. A systematic organization for the rapid collection and delivery of goods by motor-trucks, so as to relieve street traffic congestion, is a subsidiary feature of the clearing-house.

Consider first the loading and unloading equipment which Mr. Gattie advocates for a port.

Along the edge of a wharf or quay are two parallel walls, consisting of a series of arches, on top of which rails are laid upon which huge self-propelling gantry cranes travel. Between the walls are two railway tracks on which freight trains are drawn alongside berthed vessels. On the inner side

of the inner wall a building of three floors is shown. From the second floor of this building to the wall, a lean-to roof, which travels longitudinally in sections, is arranged so that any section may be moved out of the way when a crane is at work.

On the ground floor a system of continuous "trucker" belts is provided to travel longitudinally, and at suitable intervals cross traveling belts are provided. Similar travelers are provided on the upper floors. The gantry cranes are fitted with a number of "telfers," or hoists, arranged to travel along the crane cantilever arms and to pick up

goods from the holds of vessels and deliver them on shore. Each crane would handle twelve tons of cargo a minute.

How the Plan Works

The *modus operandi* is as follows: A vessel is berthed, an empty freight train is drawn up alongside, and a gantry crane runs into position opposite one of the holds. Cargo is hoisted up by the telfers, and deposited either directly into freight-cars or barges or on to a stationary platform alongside the trucker belts, on to which it is mechanically projected when required. By these belts it is conveyed and automatically transferred to the cross belts, the truckers being so arranged that goods over any particular trucker may be automatically delivered on to any cross belts, by which in turn the packages may be conveyed to any bay of the warehouse for storage, or may be delivered right away into freight-cars on the other side of the building.

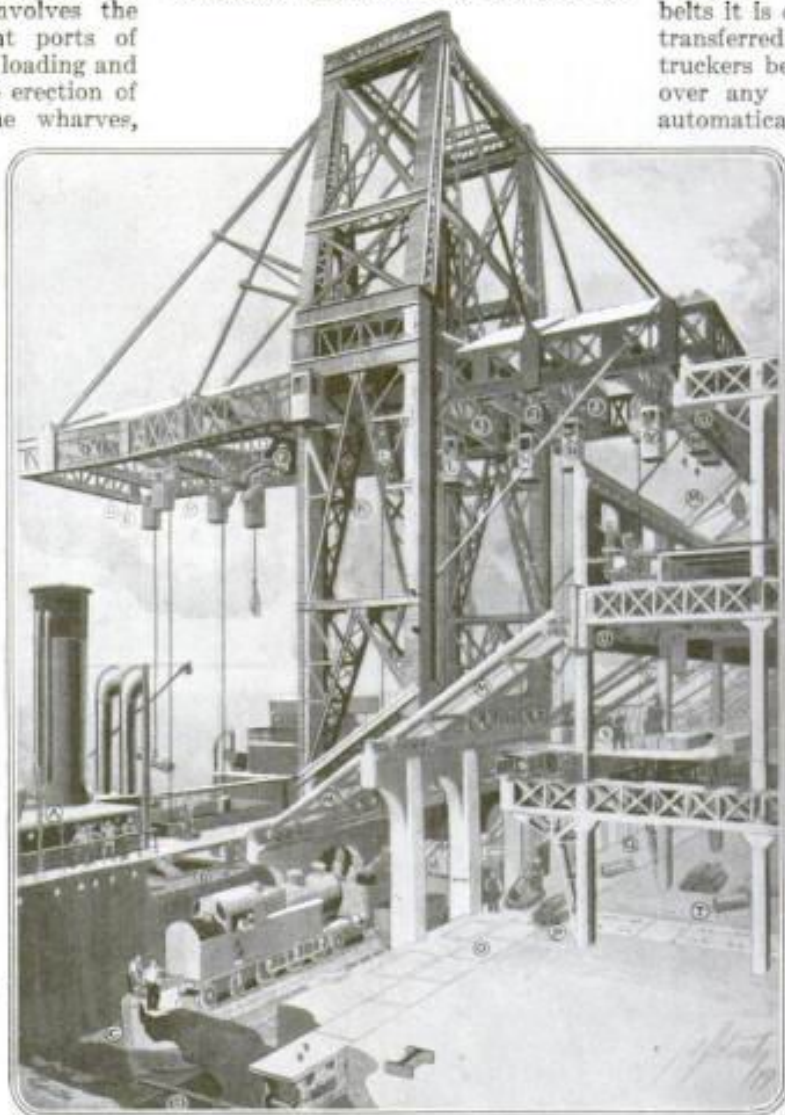
By this means man-handling is reduced to a minimum, and simply consists of adjusting the cargo slings for lifting or releasing packages, while movement of the cargo is almost continuous from the time it leaves the hold until deposited where required—an enormous advantage, reducing congestion to a minimum. To load a ship the process is simply reversed.

The Clearing-House for Freight

This in brief is the port system for the rapid loading and unloading of ships. Let us now consider the central freight clearing-house that Mr. Gattie would erect in Chicago, St. Louis, and inland towns—indeed, wherever there is an important freight junction.

In cities and large towns served by a number of important railways, each company usually runs its own freight-yard and warehouses, with the result that sometimes a great number of independent freight-yards exist miles apart.

By the substitution of a central clearing-house, land would be released for building or other purposes; freight-yard shunting—the curse of rail-

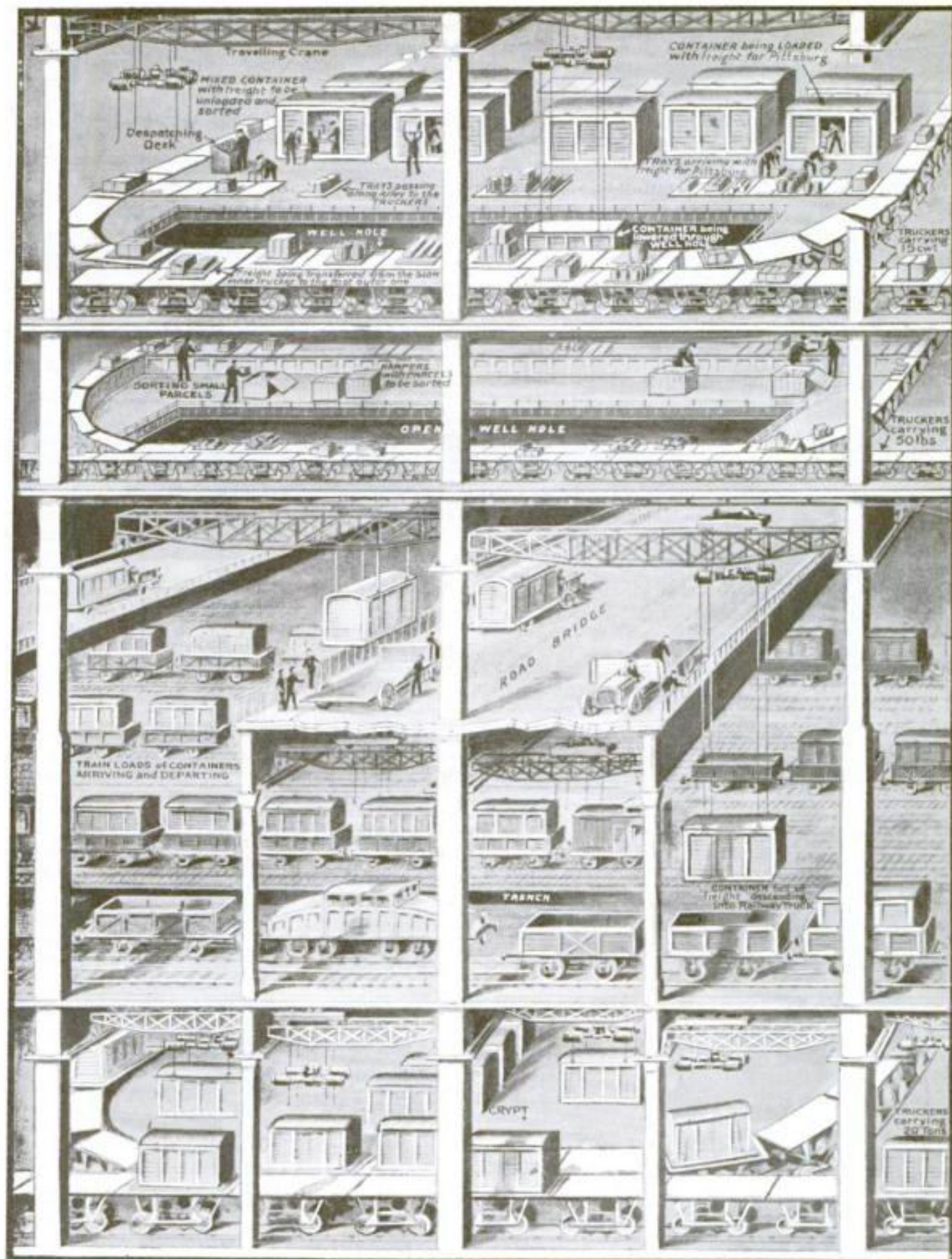


- A. Typical steamer with 9,000 tons of mixed cargo
- B. Hydraulic buffer against ship's side
- C. Barge lying between wharf and ship
- D. Lower hatchway half opened, allowing both decks to be unloaded simultaneously
- E. Traveling bridges suspend telfers over hatches
- F. Traveling bridge rail

- G. Telfer rail
- H. Point closed to lead telfer on bridge
- I. Point opened by swinging upward on a pivot built on the bridge
- J. Fixed telfer bridges
- K. Telfer lowering into barge
- L. Telfers loading trains
- M. Sliding roof sections drawn from under gantry
- N. Telfer unloading large belt stations

- O. Eight-foot trucker belt
- P. Alleyway removing goods from belt
- Q. Rail for overhead crane
- R. Telfer loading first-floor belt station
- S. Case transferring from long to short belt
- T. Alleyway discharging case
- U. Traveling crane
- V. Telfer loading second-floor belt station
- W. Spare telfers

To unload or load a ship, Mr. Gattie has invented a new type of electric crane. By bringing one of these cranes into operation over each of a ship's hatches, a large number of squads of men may be employed in loading the almost continuous series of powerful hoists each crane brings into action. The speed is limited to the quantity of goods that the men can attach to the hooks or grabs. The cranes are capable of carrying twelve tons per minute or less, the time being determined by the nature of the cargo and the labor available. It is said that nine of these cranes working over nine hatches would be capable of carrying one hundred and eight tons a minute

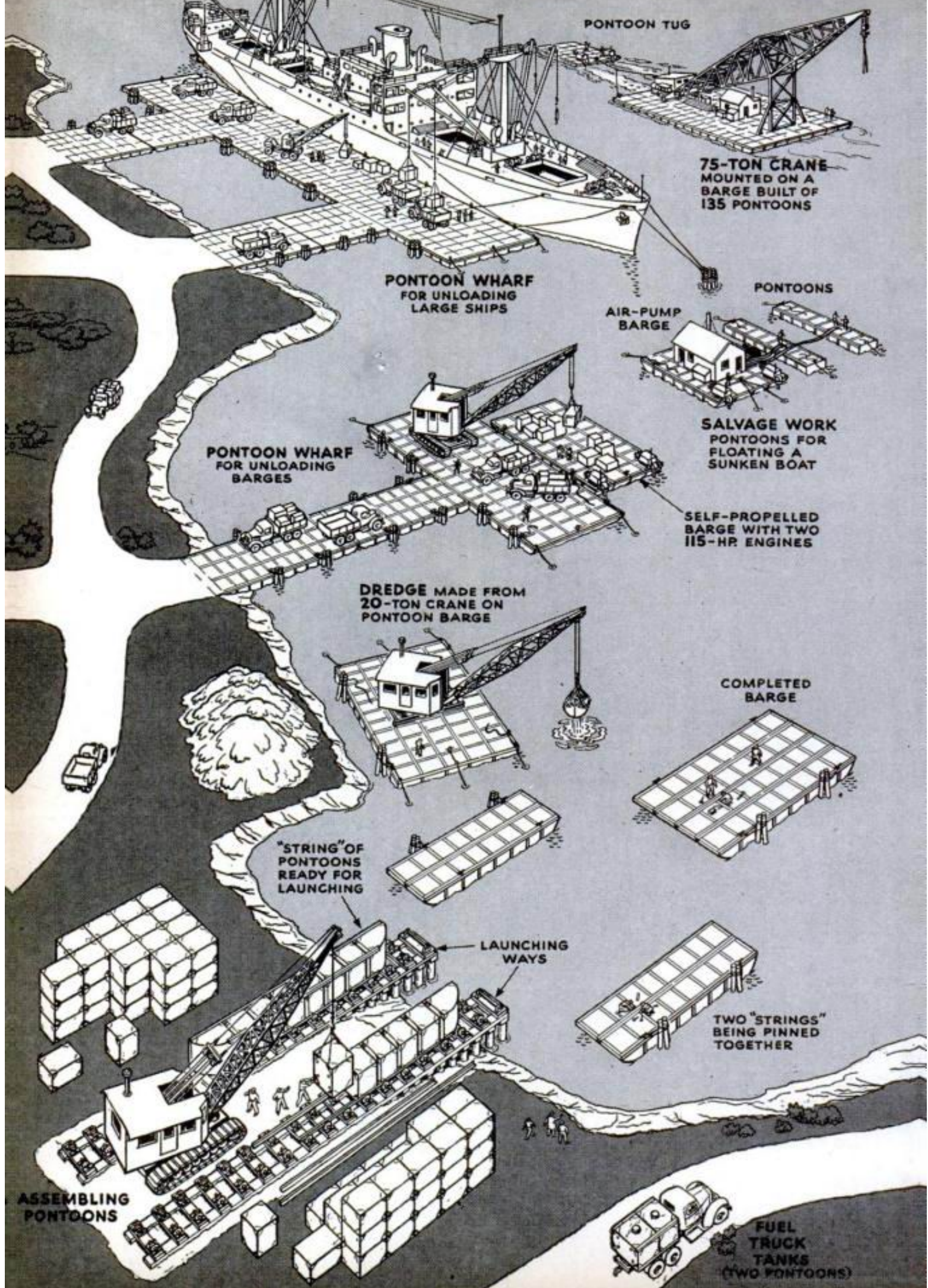


The Clearing-House for Freight

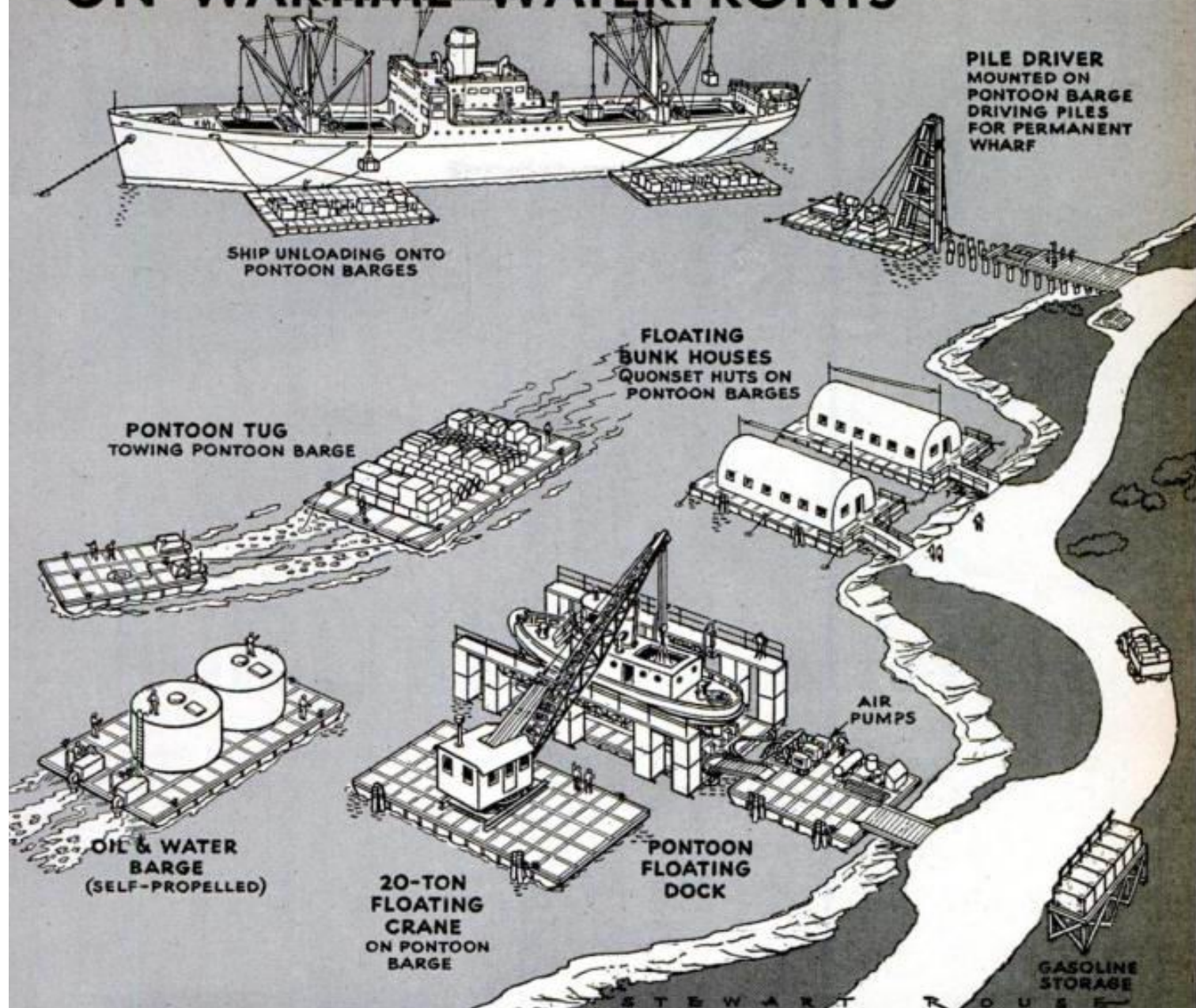
In the clearing-house all switching is avoided. Instead the container system is employed. The container can be hoisted from one vehicle to another. A train of fifty cars enters the clearing-house, stopping between two narrow platforms. Above each car is a powerful crane. The men on the platforms hook the containers to the cranes,

and immediately the train is relieved of its load. All the cars that contain through traffic for other lines are unloaded into the crypt. Powerful machinery is installed in the crypt, and any load dropped into it is immediately transported without shock or concussion to the exact box from which it can be most conveniently maneuvered

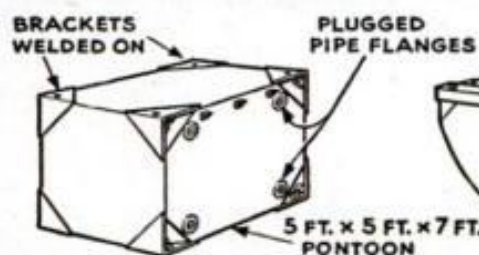
HOW MILITARY PONTOONS WERE USED



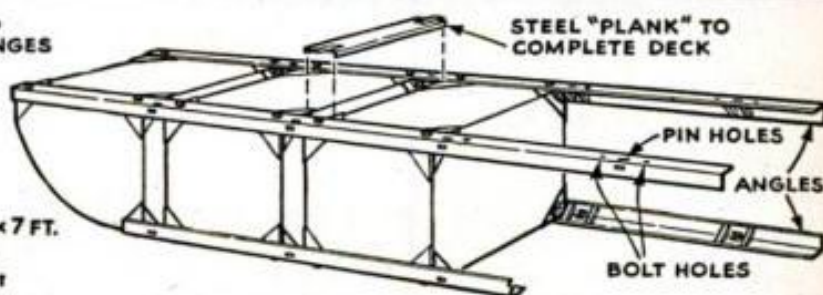
ON WARTIME WATERFRONTS



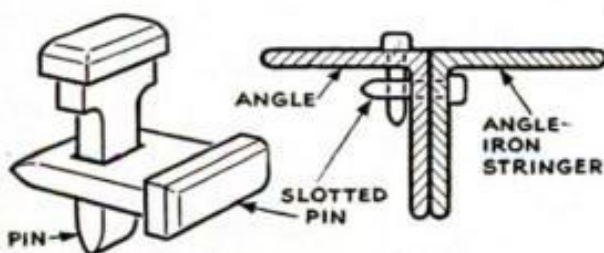
"PINNING" PONTOONS TOGETHER



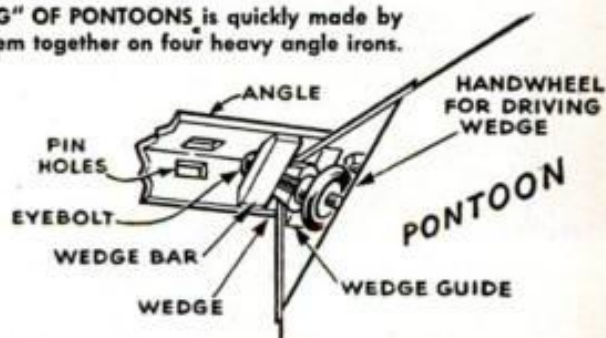
PONTOON is hollow box of sheet steel, triangle bracket welded on each corner. Bracket has bolt hole, with a nut welded to the inside of it.



A "STRING" OF PONTOONS is quickly made by bolting them together on four heavy angle irons.



ATTACHING A "STRING" TO A "STRING" to make a barge is done by mooring them alongside and linking their angle irons with driven pins (above).



TIGHTENING PONTOONS TO ANGLE IRONS is done at every corner by means of the above wedging device. Largest barges have tie rods to brace them.

WHY U.S. NEEDS MORE SHIPS

By LEON SHLOSS

Ship Illustration by M. I. COHEN

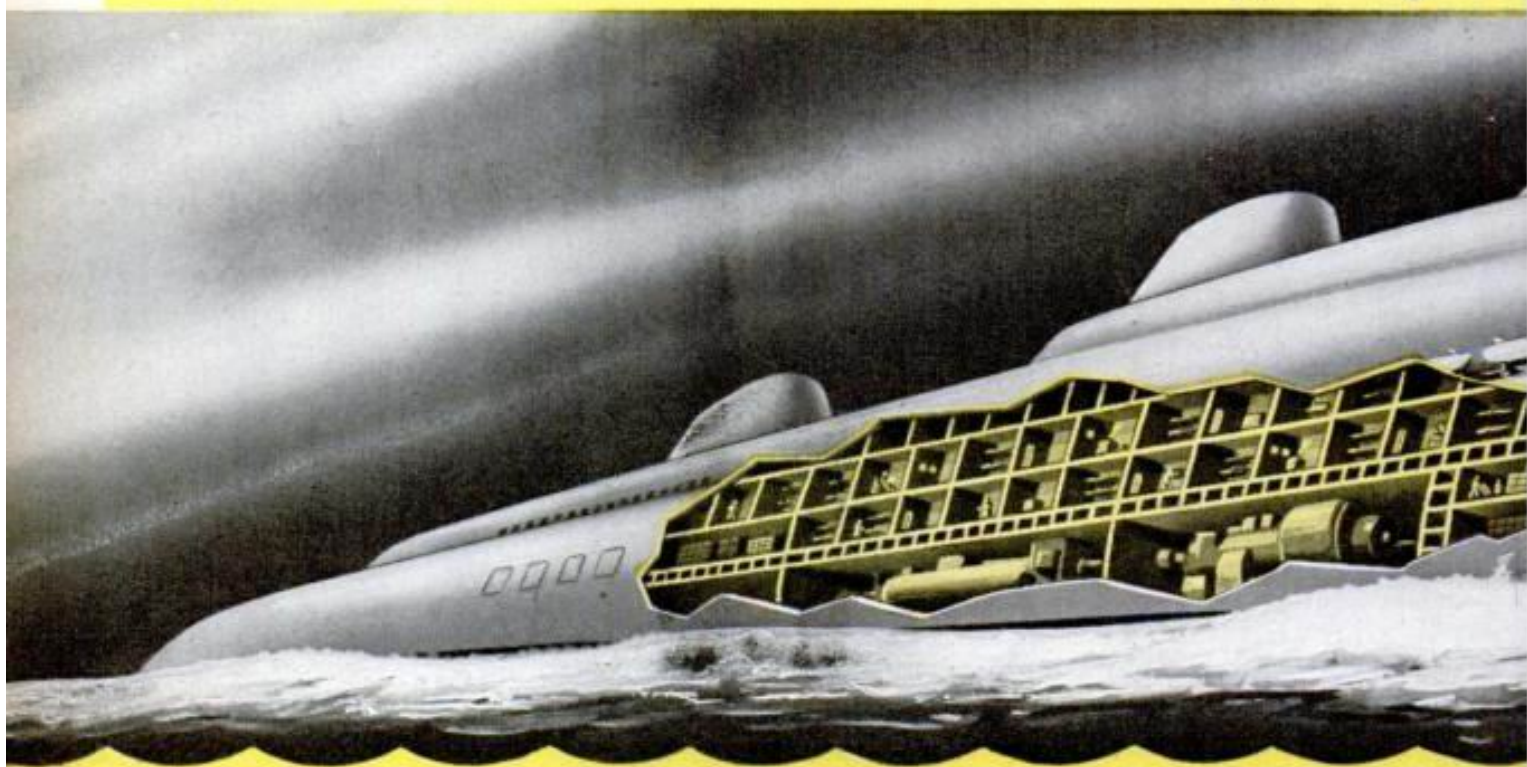
AMERICA'S postwar ocean liner will be a racy, streamlined, air-conditioned vessel 50 percent faster than her prewar cousin and packed with more comfort for passengers.

This is the superliner designed to spearhead the campaign to hold the United States merchant marine at its present world supremacy, to increase by 150 percent American prewar foreign trade carried in American bottoms, and to stave off competition by the airplane which maritime leaders admit is inevitable.

This ship is as symbolic of the future of America's merchant-marine future as the Essex-class aircraft carrier was of U. S. victory in the war. On the new liner's performance are pinned this country's hopes in the race for trade against the rest of a world which, through outright loss of prewar merchant tonnage, will build new, passenger-pleasing craft. If internal and international politics force America into the race with nothing but conversions from the nearly 45,000,000 tons of existing tonnage, government maritime leaders believe its present dominant position will be lost.

Three times in less than a century the United States has gained maritime ascendancy, twice lost it. In 1850, this country carried 70 percent of its ocean-going trade in its own vessels. By World War I, this figure had dropped to 10 percent. In that

Superliners for Main Ocean Highways



war, foreign powers withdrew their vessels for war uses and America spent \$3,000,000,000 building a merchant fleet. When the war ended, this fleet was scrapped, laid up, or sold for a song.

World War II found us with an 11,000,000-ton merchant fleet, 90 percent obsolete, and carrying only 20 percent of our foreign trade. Again, a new fleet had to be built.

Reckoning losses, and obsolescence, the merchant fleet now totals 45,000,000 dead-weight tons, approximately 135,000,000 displacement tons. These ships, used according to plans laid by the Maritime Commission, will assure America's place in the cargo trade. These plans cover nearly 2,000 sailings a year over 35 strategic routes. These are the famous C-ships (C-2, C-3, C-4) developed by the Commission—with speeds up to 18 knots.

But these vessels will not compete in speed, appointments, and efficiency with the passenger liners that competitor nations are planning today. Germany and Japan are out of the picture. Italy's future is questionable. But Great Britain, Sweden, Norway, France, and Holland loom large in the maritime picture, with Britain the sternest competitor, while through the sky streaks the greatest threat of all—the airplane.

The immediate future will see a spirited contest between Britain and America, growing out of some very astute maneuvering on both sides.

The British did a rather sketchy job of converting merchant tonnage to war use. This can be seen in the *Queen Mary*, on

WAR SHIPPING WON'T HOLD WORLD TRADE

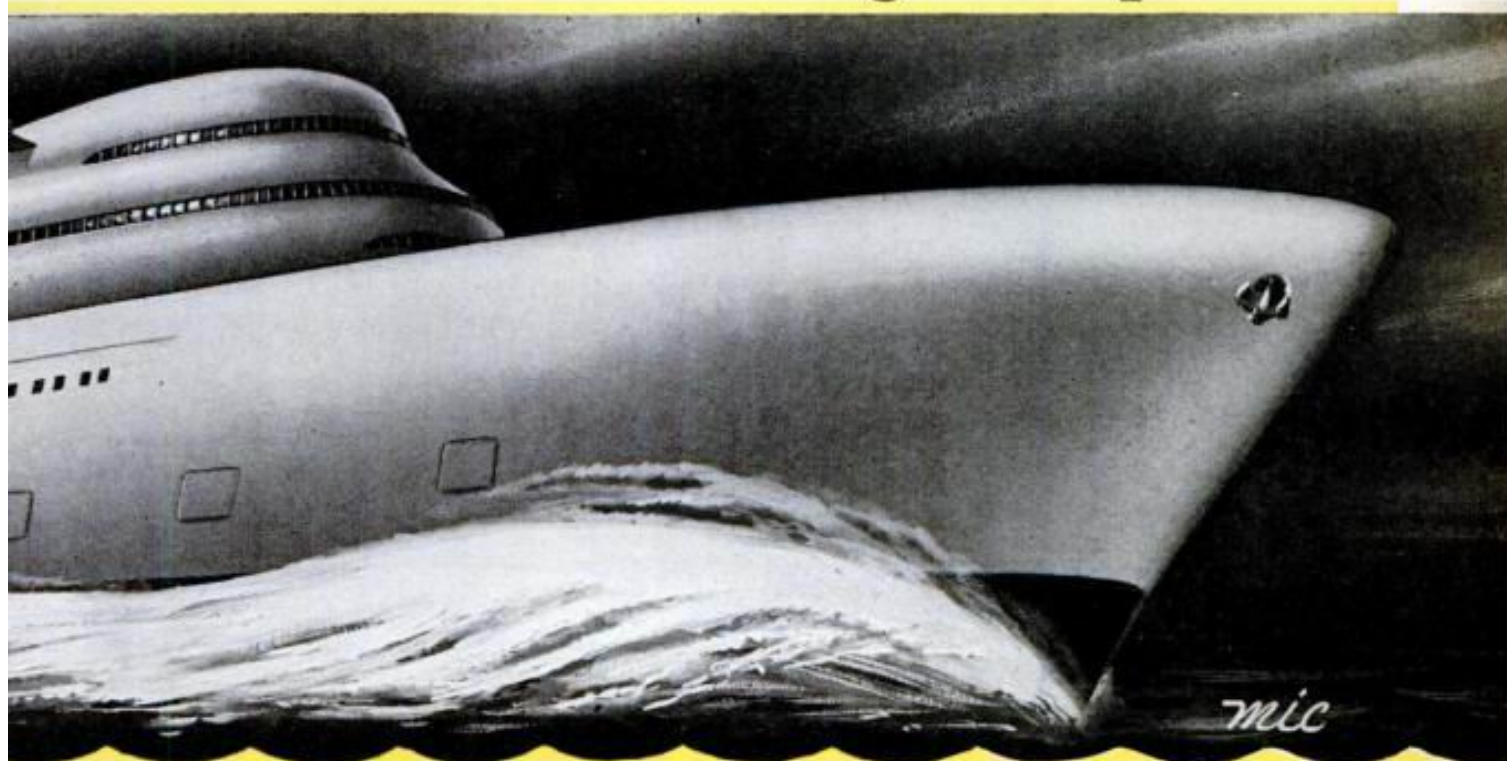
This country has just finished the biggest shipbuilding job in the world. More ships, aggregating more tonnage, now float under one flag than ever before. But war-built bottoms cannot compete in a peacetime economy with either the airplane or the subsidized liners of other maritime nations. With all our ships, the U. S. must build *still more ships* to protect its investment in world trade.

The Editors

which little more than replacing bunks with beds, and hanging stateroom doors, is necessary to get the *Queen* back in the luxury business. Meanwhile, this country virtually tore down and rebuilt its ships, installing many semipermanent features. Obviously, the British thus gained an advantage.

But the Maritime Commission wasn't idle. After the Liberty- and Victory-ship designs were perfected and war shipping was pretty much on an assembly-line basis, the Mari-

Can Meet Air and Foreign Competition



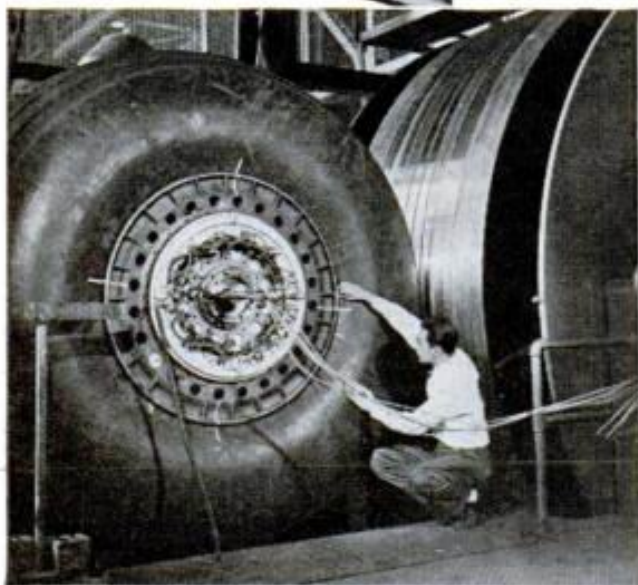


Speaker in Dome

FOR pilot's convenience and safety, the radio loud-speaker is installed in the new Stinson Voyager's dome. Cabin is soundproof.

Two Tugs, It's On

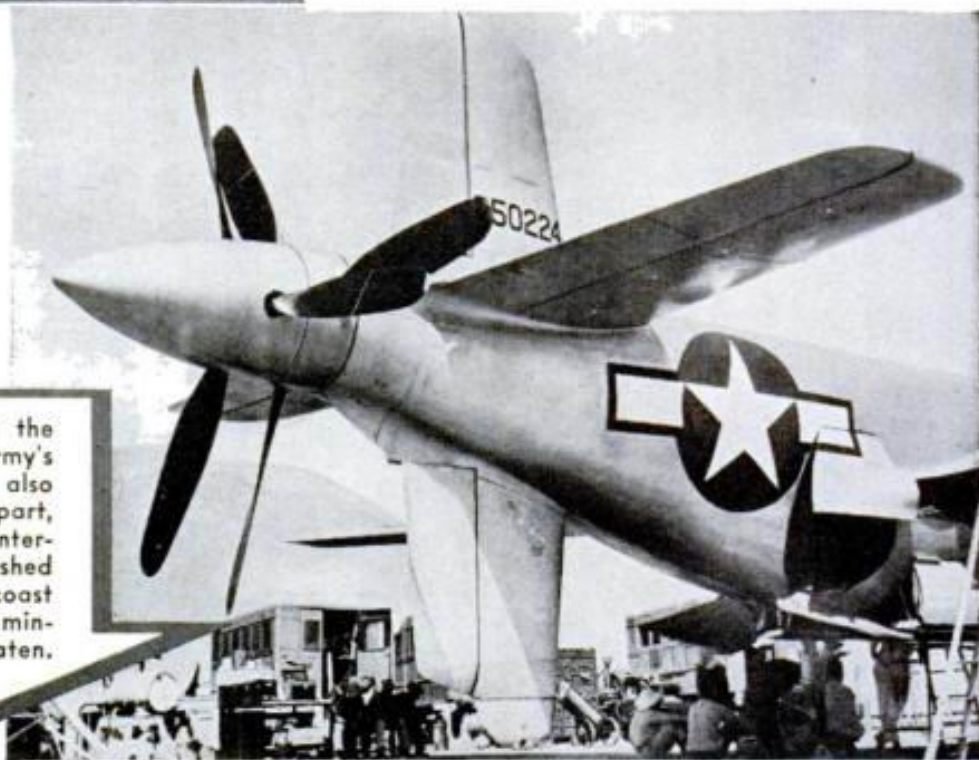
A TUG at the leg and chest straps quickly and easily makes the Pioneer 'chute harness fit. At right, pilot loosens leg straps.



Dynamometer Tests Giant Tires

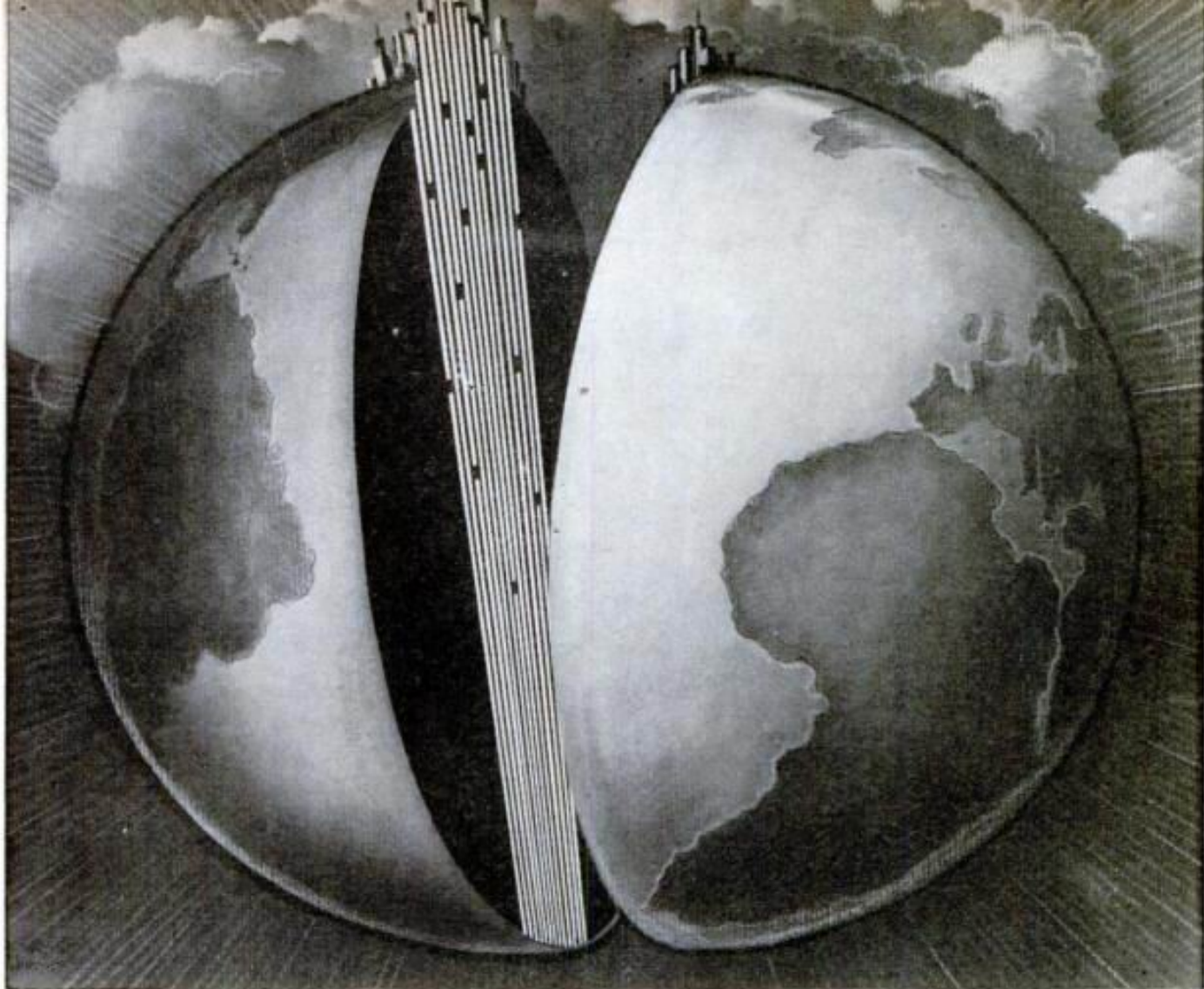
A THREE-QUARTER ton tire of the type used on giant bombers is tested on the world's largest dynamometer, the machine that checks the strength and operating characteristics of new airplane landing-wheel, brake, and tire assemblies. The 110-inch tire is slammed against the 158-ton steel wheel, shown in the photo, as the wheel speeds around at two miles a minute, simulating actual landing conditions without risking personnel or equipment.

Here is the tail of the prototype of the Army's XB-42 Mixmaster and also its commercial counterpart, the DC-8. The twin counter-rotating propellers pushed the ship nonstop from coast to coast in 5 hours 17 minutes, a record later beaten.



DOUGLAS DC-8 TRANSPORT





Hard-working passenger elevators pile up enormous mileages. In New York City alone, they travel daily a distance equivalent to 13 trips through the earth, lifting and lowering more than 10,000,000 people.

VERTICAL RAILROADS

Their Traffic System Protects Millions of Passengers Going Millions of Miles a Day.

By **FRANK ROWSOME, JR.**

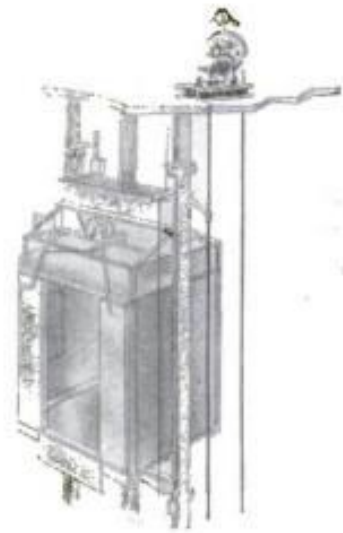
AMERICA has a transportation system which, in New York City alone, carries four times as many passengers every day as all Class I railroads. Ten million people a day are lifted or lowered 95,000 miles by New York's elevators. These short-haul, indoor, vertical railroads—most appreciated when stopped by a strike—have added a new dimension to our cities. Without them, few buildings would be more than 60 feet high because people display a marked reluctance to climb more than five flights of stairs.

Barring such events as a bomber going through a building and cutting both the

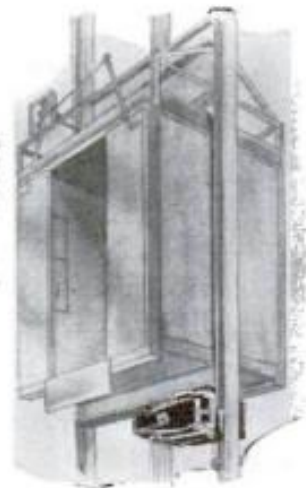
hoisting cables and the governor cables, accidents are rare. Cables are made from five to fifteen times stronger than they need be to carry maximum loads, and modern elevators have elaborate mechanical and electrical safeguards against all predictable hazards.

Each time a car moves, strong electrically actuated brakes stand ready to stop all movement of the hoisting sheave. The brakes are so designed that electromagnetic force is used to release rather than to apply the needed friction. Hence, an accidental current interruption involves no risk. Sometimes the hoisting motor is wound to give regenerative braking: that is, it automatically changes to a generator whenever it is

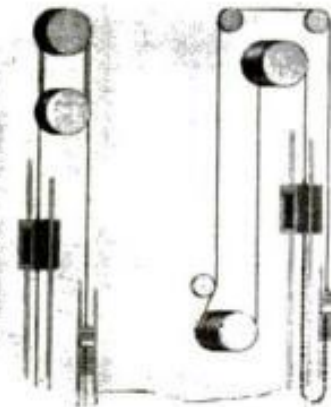
MODERN ELEVATOR SAFETY DEVICES



The overspeed governor works on its own separate cable. If a set maximum is exceeded, it slows the car.

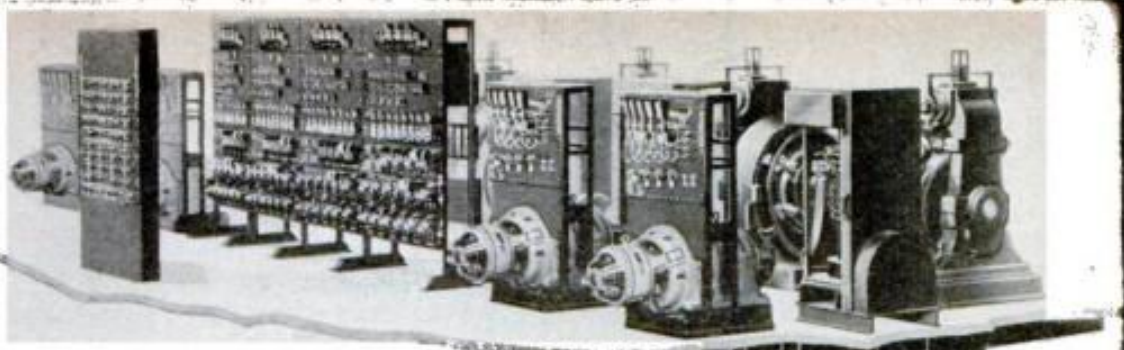


If the governor cable locks, this device beneath the car clamps powerful jaws against a rail, stopping elevator.



The traction drive, left, is contrasted schematically with a drum drive using power applied from basement.

Elevators made skyscrapers possible, but behind-the-scenes equipment and its space requirements limit the height of modern buildings.



Courtesy Westinghouse Electric Elevator Co.

The complexity of modern elevators is concealed from passengers' eyes. In the telescoped phantom view at right, the running gear of only one car is shown. Note the oil buffer at bottom of the shaft.

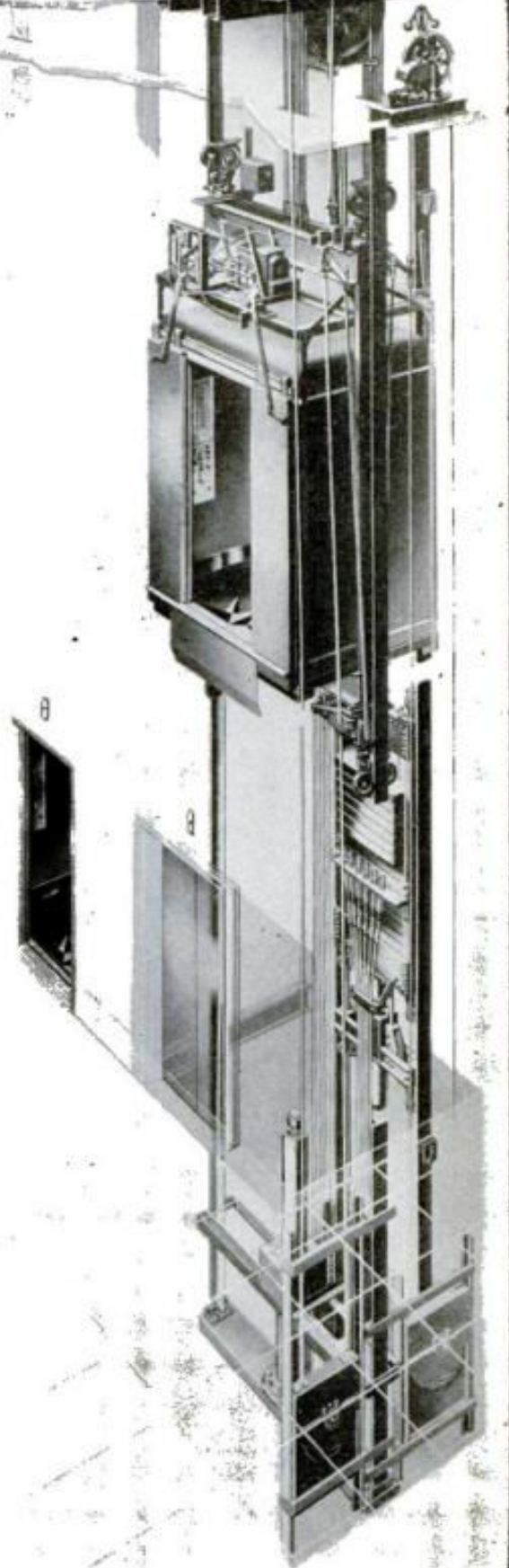
rotated by an external force. This creates a powerful braking effect that saves wear on the ordinary friction brakes.

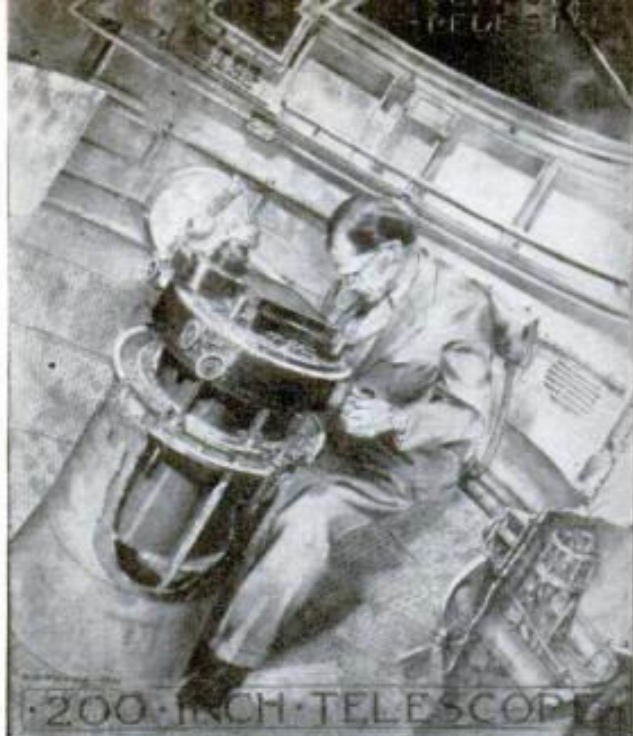
The first real safety device, invented by Elisha Graves Otis, was exhibited in 1853. Otis had himself hoisted well off the ground in an open elevator frame, and in full view of hushed onlookers began chopping at the supporting rope with an ax. When the rope snapped, the platform dropped only a short distance before it locked itself rigidly on the guide rails. Mr. Otis then straightened his stovepipe hat and received the applause of the multitude.

The guide rails had a saw-toothed edge that was automatically grabbed by a mechanism on the platform when the cable slackened. Such a stop had practically no resiliency and was soon discarded for more gradual methods of applying braking friction. Safeties operating on the rails are now standard equipment, however, and they operate with a fine precision.

The air cushion, at one time considered a highly effective safety, made use of the compressibility of air beneath the car to give it protection. The lower portion of the hoistway was built to conform closely to the car, and spring- or oil-retarded bumpers were installed in the pit. Air valves were provided near the bottom of the shaft, both to prevent too rapid a stop and to admit air for upward travel.

A car was once experimentally dropped 287 feet into a 50-foot air cushion without breaking a basketful of eggs inside. One of the cushion's promoters dropped 20 stories and landed uninjured, but with the chair in which he was sitting festooned about his ears. Some elevators are still protected by air cushions, but the system is out of favor now. A cushion will operate nicely enough if the lower doors don't blow out, but there is some difficulty in adjusting the air valves





LOOKING DOWN into the telescope's eye, the observer may focus it on stars a billion light years away. Cylinder supports a double-slide plate holder.

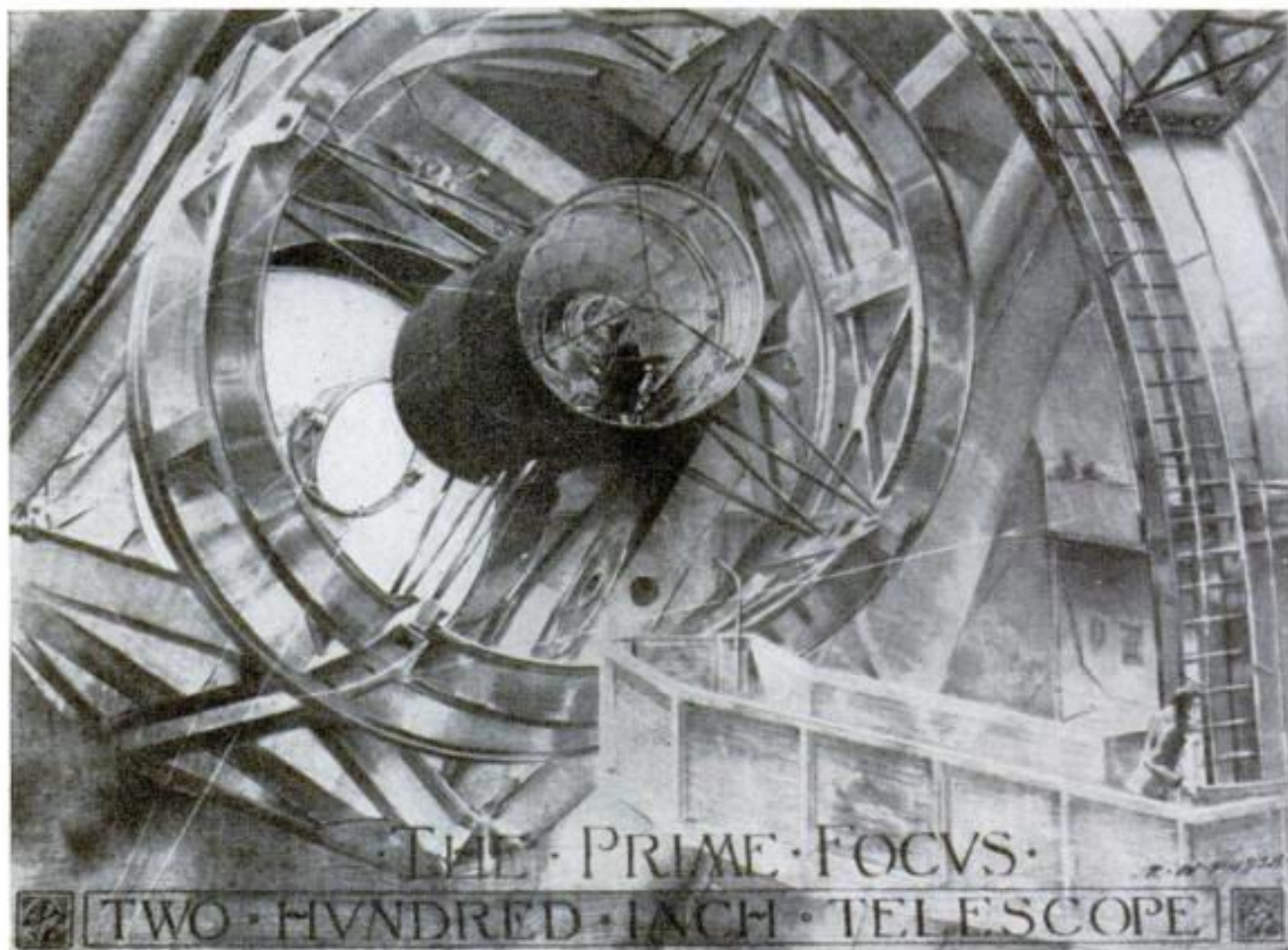
A MOVABLE BRIDGE, riding on a curved track, will take the astronomer to and from the prime focusing point at upper end of the tube. Huge mirror reflects light to photographic plates.

INSIDE THE

THE great 200-inch telescope of the California Institute of Technology on Mount Palomar in southern California is now scheduled to go into action in about 18 months. World War II, draining the nation's scientific talent, abruptly halted the construction of the biggest spyglass in the world. Now, experts have resumed the task of completing it. The cover of this issue of **POPULAR SCIENCE MONTHLY** shows how the instrument will look. A dome 10 stories high will house it.

To give an idea of the power of the 140-ton tube, it would make New York's Empire State Building visible from the moon, in the absence of intervening clouds and haze. New light will be thrown upon the possibility of life upon our neighbor planets. To astronomers, one of its most interesting uses will be to discover almost inconceivably remote galaxies or universes. For comparison, our own galaxy is the Milky Way, in which the sun is a typical star.

In theory, since the light-collecting power increases according to the square of the diameter, the Palomar instrument should



WORLD'S BIGGEST EYE

prove four times as powerful as the 100-inch Mt. Wilson telescope in current use. Actually, later refinements in steady mounting will probably better the figure. This becomes especially important in taking long "time-exposure" pictures of faint stars.

Observers at Mt. Palomar will rely almost exclusively upon photographs for their

records—for the eyes of different people do not always see alike. Some see canals on Mars. More skeptical stargazers believe that the markings of the red planet are exaggerated and joined by the imagination of the viewer, much as the ancients saw wild beasts and mythological characters in constellations or star groups and recorded

A TEN-STORY DOME will house the 200-inch telescope. The dome weighs 1,000 tons and the instrument 500 tons. Cutaway sketch shows the principal features and three of the positions of the upper end of the 140-ton tube. These drawings were made by Russell W. Porter of California Institute of Technology.

PHANTOM DRAWING SHOWING HOW THE OBSERVER GETS ON AND OFF THE TUBE

CRANE TRACK

TELESCOPE CAGE

PRIME FOCUS
f/3.3

60-TON CRANE
COUDE & CASSEGRAIN
MIRRORS

HORSESHOE,
NORTH POLAR-
AXIS BEARING

DECLINATION
AXIS

NORTH
PRESSURE
BEARINGS

200-INCH
MIRROR

NORTH PIER
CASSEGRAIN
FOCUS f/16

NORTH
CONTROL DESK

DOME
DRIVE

DOME
TRUCKS

ELECTRICAL
CONTROL PANELS

PRIME-FOCUS
PLATFORM

DOME, 137-FT
DIAMETER

DOME SHUTTER
30-FT OPENING

RIGHT-ASCENSION
DRIVE

PASSENGER
ELEVATOR

OUTSIDE & INSIDE
DOME BALCONIES

COUDE FOCUS
f/30

CONSTANT-
TEMPERATURE
ROOM

OBSERVATORY
WALL

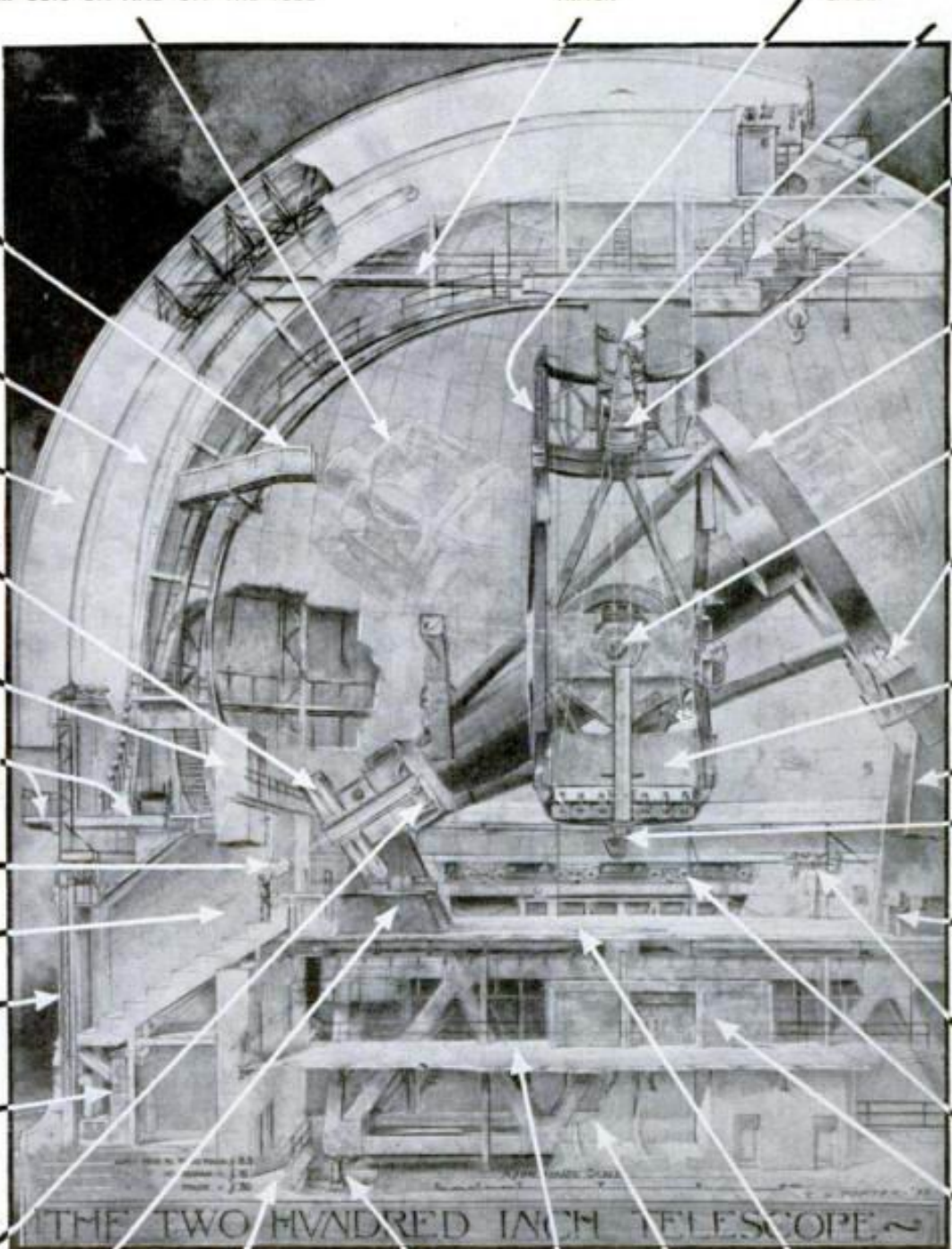
AIR-
CONDITIONING
DUCTS

SOUTH
POLAR-AXIS
BEARING

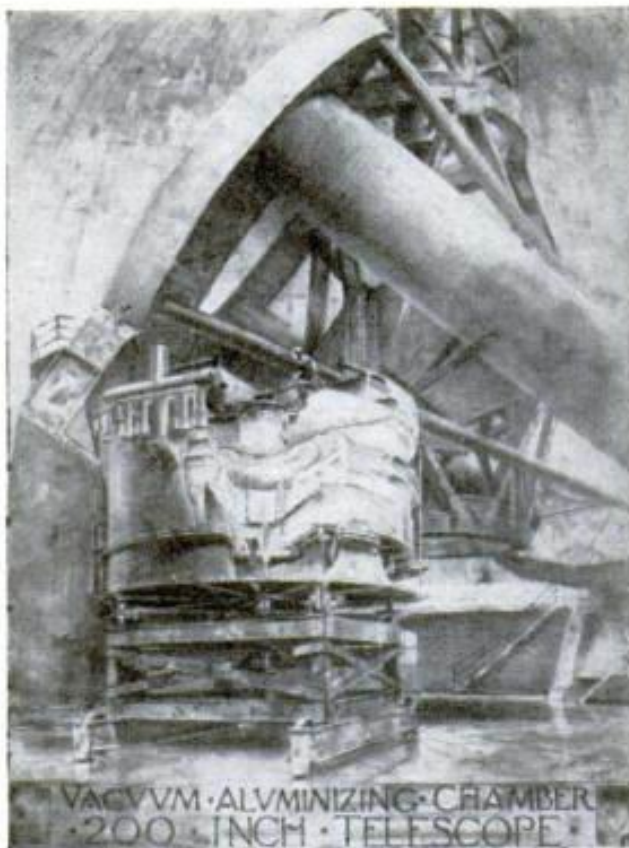
BASE-FRAME
SUPPORTS

OFFICES

OBSERVATION FLOOR

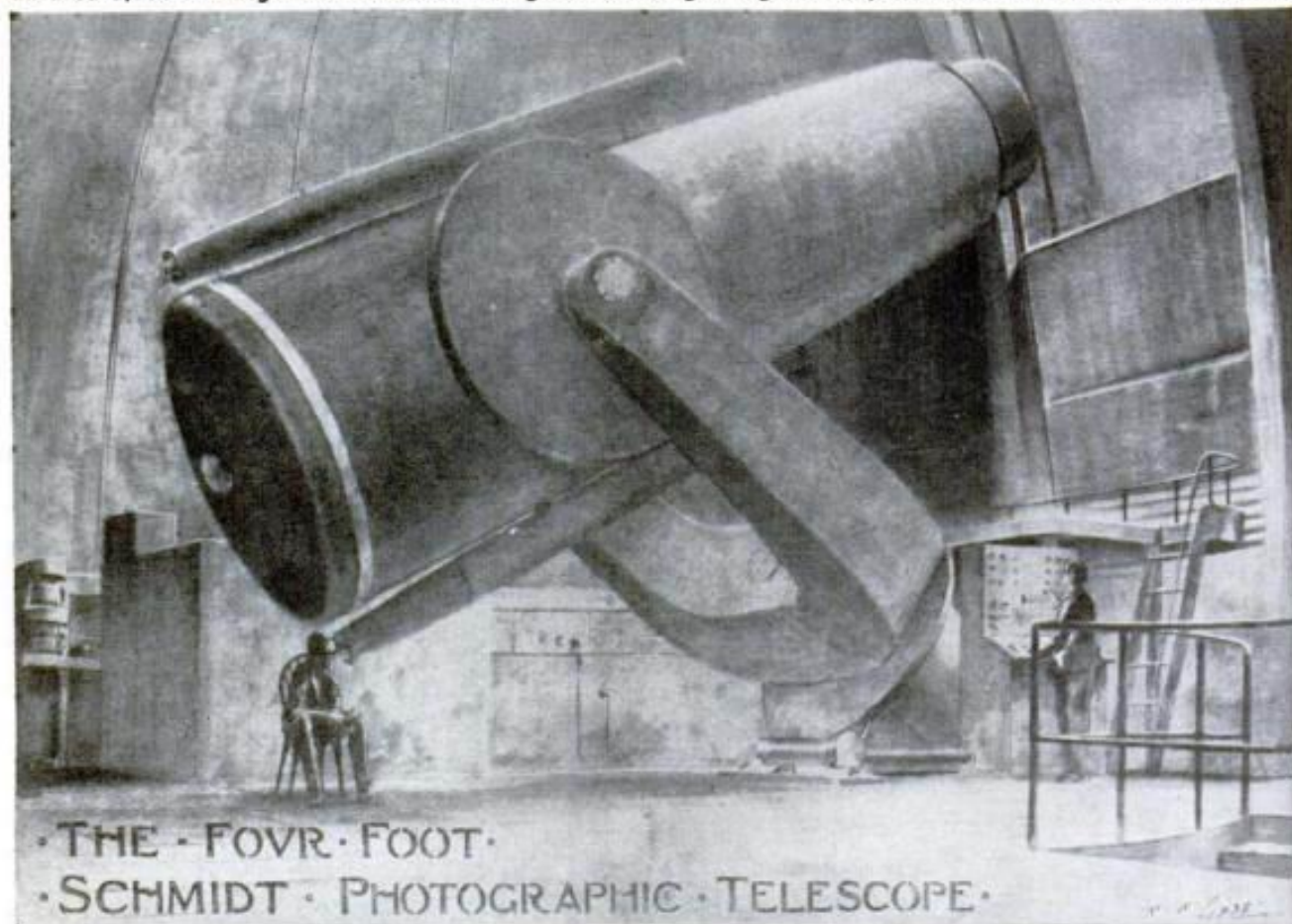


THE TWO HUNDRED INCH TELESCOPE



MIRROR SURFACE of special aluminum may be renewed at the site. Mirror will not vary from perfection by more than two millionths of an inch.

SCOUTING TELESCOPES will find objects worthy of the great eye's time. This one will photograph an area 3,000 times greater than 200-inch giant. Note guiding telescopes above and below camera tube.



them on the decorative charts of the day.

To obtain its enormous magnification at its principal focus or observing position, the sky camera receives a cone of light only one fifth to one third the width of the full moon. Therefore, smaller "pilot telescopes" direct the big one. Carefully balanced, its barrel rises and falls, and the whole dome revolves with it, virtually without friction, on films of oil forced through bearing pads.

Not only will stars and nebulae pose for their pictures, but their light will be transformed into a spectrum or rainbow, permitting the observer to see what they are made of. Celestial events, such as the birth of novae or exploding stars, will be filmed as they occurred in prehistoric times, since photographs will pick up stars so far away that their light takes 1,000,000,000 years to reach the earth.

Like other great telescopes, the one at Mt. Palomar employs a concave mirror to form an image. Varying the optical system provides a number of observing positions, including those familiar to astronomers as the prime focus, the Cassegrain focus, and the Coudé focus. These are indicated in an accompanying drawing, together with their speed rating in the "f" system in general use by photographers. Low numbers mean short exposures.

STOP GAP

HOUSING

MILLIONS OF FAMILIES CAN'T
WAIT FOR PERMANENT HOMES

By HARTLEY E. HOWE

BY DECEMBER, 3,500,000 American families will have no homes of their own. Two thirds of them probably will be veterans. For all, home will be a bedroom in someone else's house. More families will be doubled up than there are in New York, Chicago, and Philadelphia put together.

That's why we need stopgap housing.

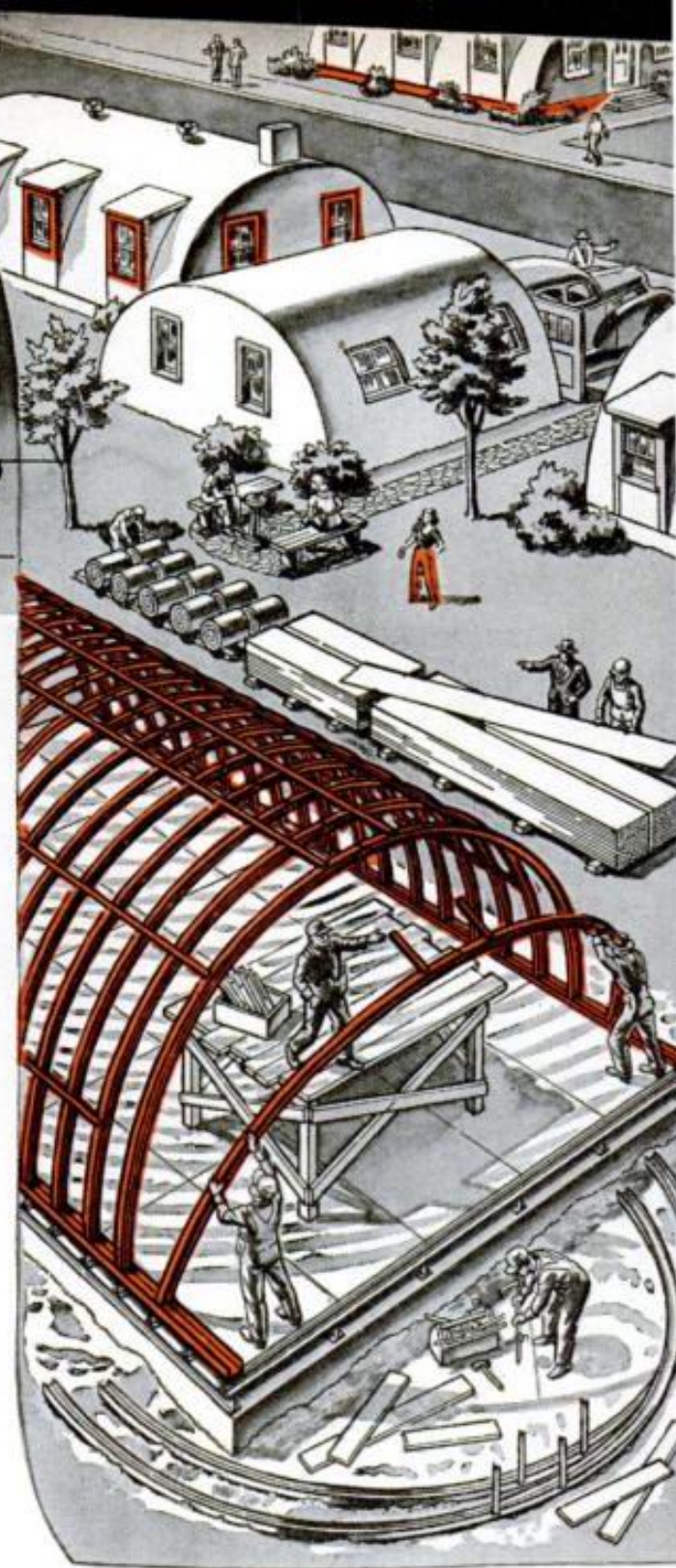
The Federal Public Housing Authority is struggling to provide it. Former Navy men are going back into Quonset huts—and liking it. Ex-GIs are moving back into Army barracks—this time with their families. New, strange-looking communities are springing up all over the United States.

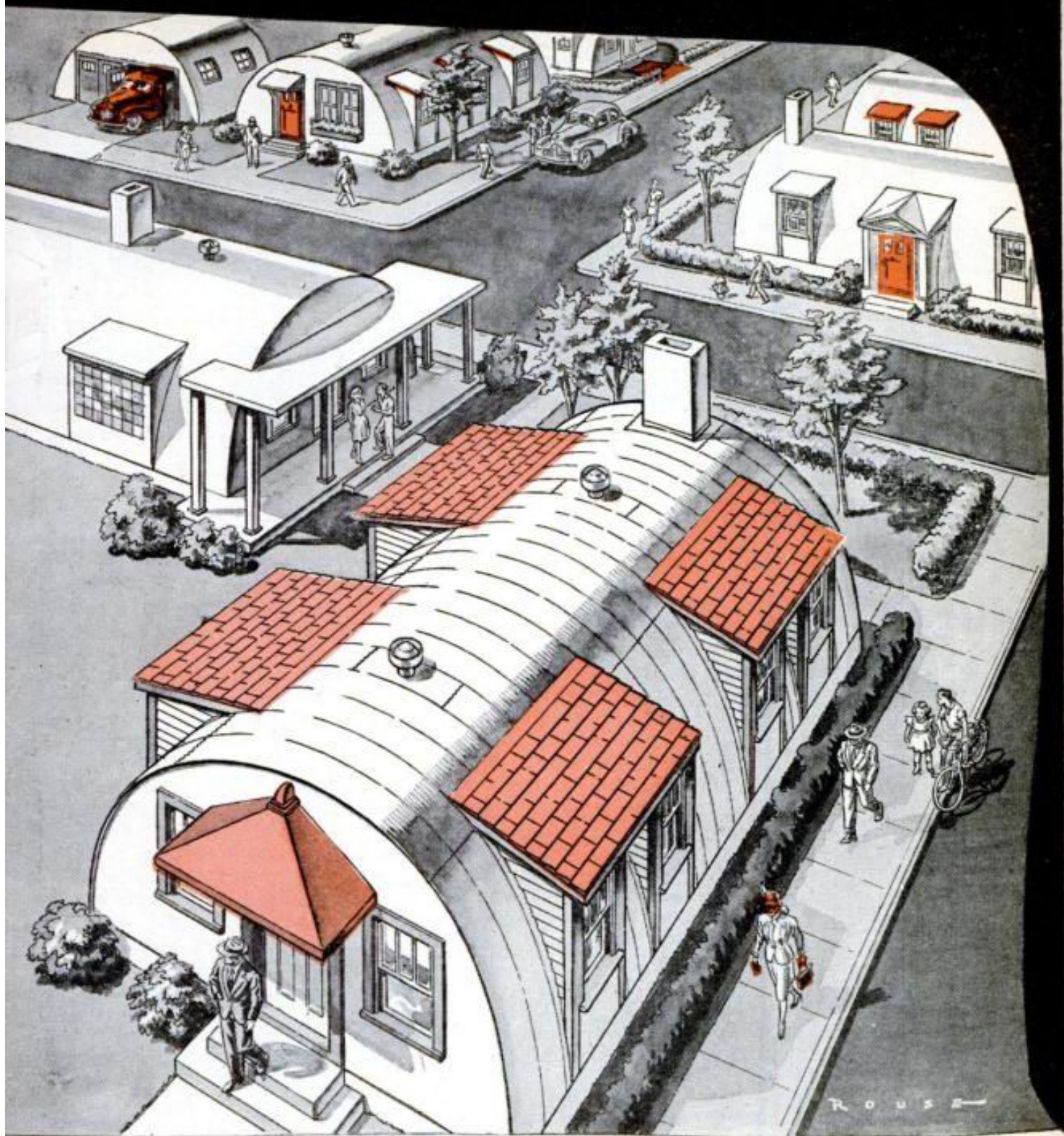
The program now promises a home to only one family out of 31. But it's a start. A high wartime marriage rate, mass migration from country to city, the wartime halt in normal residential construction and repair—all these factors have combined with the sudden demobilization of millions of men to create an unprecedented housing shortage. Even if 1,200,000 permanent homes are now built every year—and the United States has never built even 1,000,000 in a single year—it will be 10 years before the whole nation is properly housed. Hence, temporary housing is imperative to stop that gap.

So far there are seven different kinds of temporary housing available. All are wartime varieties that have been declared surplus and are being distributed by the Federal Public Housing Authority for the use of veterans. FPHA pays for dismantling the buildings, shipping them to new locations, and re-erecting them. The applicant—a college, municipality, or other nonprofit

body—must provide the site, streets, and basic utility installations, as well as the management and maintenance expenses. The applicant also agrees to remove the temporary buildings after the emergency has passed. No profit is permitted on the rental of the houses; any surplus remaining after operating expenses must be turned over to the United States Treasury via FPHA.

The Navy's contribution to the stopgap program is the familiar Quonset hut, used by the services from the tropics to the Arctic. The armed forces bought 155,000





of these during the war, but 85 percent went overseas and only 5,000 of the remainder have been released as surplus. The veteran who moves his family into one of them will find it very different from his rough quarters overseas. The surplus units are all the 20-by 48-foot type used by the Navy itself to house 6,000 families of men on temporary duty at home bases. Each Homoja hut (compounded of the names of Admirals Horne, Moreell and Jacobs) is completely lined, insulated and floored, and divided into two apartments. Each apartment has two 12-by

8-foot bedrooms, a living room, small kitchen area, and shower bath. Such homes, including household equipment and utilities, cost the Navy between \$3,000 and \$3,300 a family and rent for \$1 a day.

Army men will also find familiar buildings in the stopgap program. Surplus barracks, many of the one-story type, are being called back to active duty for veterans' housing. A 30-man barracks can be divided into three apartments, each with two bedrooms, kitchen, living room, and bath. Unlike the Quonset huts, these buildings are not de-

Six thousand families, two to a 20-by 48-foot Quonset hut, live in the Navy's Homojia villages. This hut was named in honor of Jefferson Rahill, seen in his carriage.



mountable. They must be ripped apart by power saws and then nailed together again at the new site, but an outside sheathing of shingles or clapboards makes them attractive.

Five other types of stopgap housing were developed by the Federal Public Housing Authority for war workers in congested production centers. Congress has provided \$191,000,000 to pay for moving 100,000 of these units, no longer needed for war workers, to new sites.

Temporary family dwelling units, which come in one-story and two-story sizes, are of light frame construction, covered with such materials as wallboard, plywood, and gypsum board. Already divided into family units, they require no interior conversion. They must be cut into panels for shipment to new sites.

Portable shelter units look like overgrown tourist cabins. Each shelter, holding a single family, has either one or two bedrooms.

War dormitories, either single- or double-storied, were planned for workers without families, each man being allotted a single room. Some buildings, especially those used for college housing, will probably be left this way for single veterans. Many, particularly the one-storied type, will be converted for family use, a two-bedroom apartment taking the place of six individual rooms. Each building must be panelized for shipment.

FPHA built 321,000 of these three types of building, of which more than 35,000 have now been put into use again for veterans.

Two types of trailers are also available. The standard variety is a conventional auto trailer, measuring 8 by 22 feet and housing three people. The expansible trailer is about the same size when folded up but blossoms out into a small house holding four or more persons. Both types are mounted on wheels for transportation, then hoisted on wooden horses at the new site. Thirty-five thousand

trailers were used by FPHA in its war-housing program: more than 11,000 of these have been redistributed for stopgap homes. All are out on loan only and must eventually be returned to the agency.

The only other FPHA type that does not have to be cut up for shipment is the demountable house. This is a prefabricated, two-family, one-story building designed to be taken apart and re-erected wherever desired. Seventy-four thousand were built for war housing, but since the communities where they now are have first call on these houses it is uncertain how many will be available for stopgap housing.

These demountable homes must be paid for by the communities that acquire them, since, unlike all other emergency types, they are considered permanent residential units. The other varieties have a short life span; they were skimpily built to conserve scarce materials during the war. Only one tenth the framing lumber of normal buildings was used in them. Many units have no gutters or downspouts. Some have no bathtubs, only showers. Heating is mostly by small oil stoves. The number of cubic feet per occupant is frequently below modern standards.

But it is still better housing than many so-called permanent homes. Despite our much-vaunted American standard of living, a third of our nonfarm homes have no bathroom and 28 percent lack even a private flush toilet. Nearly four million need major repairs and of the remainder more than 3,100,000 have no running water. In contrast, stopgap housing seems homelike.

FPHA believes that much of its temporary housing will have a useful life even after it is scrapped as homes. From panels ripped from temporary buildings the agency has built full-size demonstration models of tourist cabins, roadside stands, chicken houses, ranch bunkhouses, garages, light-plane hangars, and other such structures.

Some city planners fear that stopgap-

POPULAR SCIENCE

MAR. 1946
25 CENTS

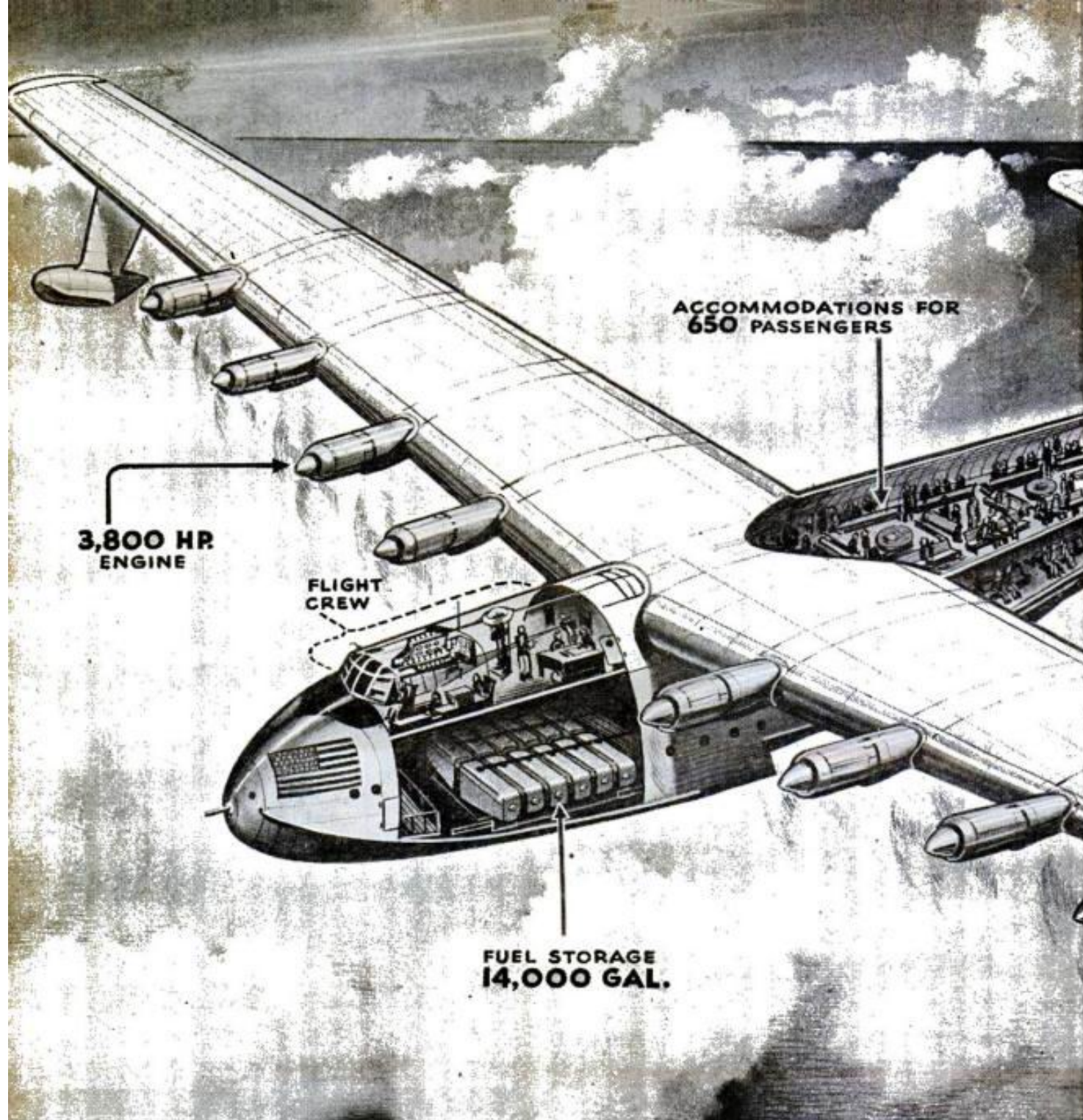
MONTHLY



STOP GAP
HOUSING — p. 66



Circulation This Issue Over 1,000,000



This cutaway drawing of Howard Hughes' H-4 shows the vast interior that could hold a payload of 60 tons.

Looking Inside the

Howard Hughes' all-plywood flying boat, with eight 3,000-hp. engines, will fly 3,500 miles fully loaded.

Drawings by ERIC SLOANE

UNDER secret construction for almost three years, the world's biggest airplane has just been revealed in all its giant proportions. It's the \$20,000,000 mystery ship on which Howard Hughes has been working, with Henry Kaiser as a partner until a while back, and is now called merely the H-4.

We thought the Superfortress a pretty fair ship for size, with its 141-foot wing



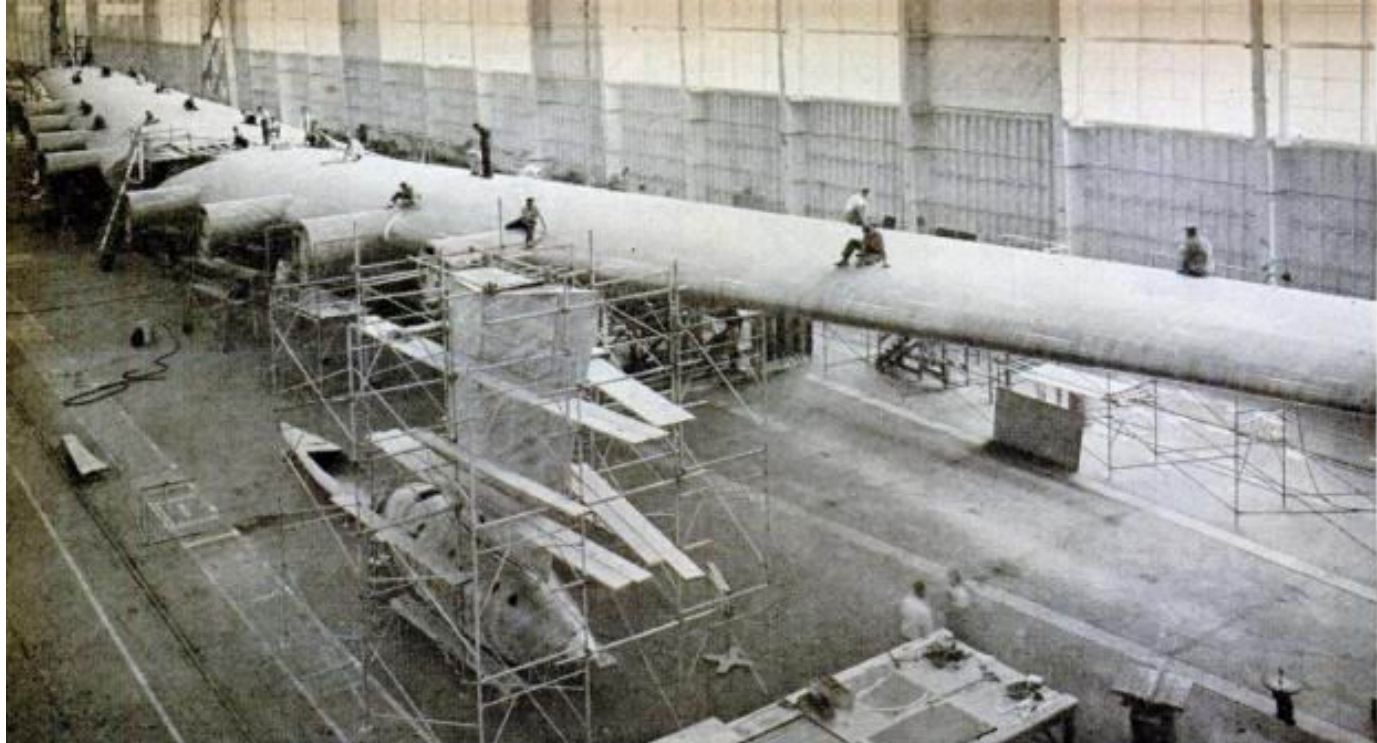
The giant could be a cargo carrier, transport, or hospital ship, and fly nonstop from Honolulu to Tokyo.

World's Largest Plane

span. But the H-4 is big enough to accommodate a Superfort on each wing with room to spare. It has eight engines with a total horsepower of at least 24,000.

The giant's wingspread is 320 feet—longer than a football field. Its hull—it's a flying boat—is 220 feet long and about three stories high. Gross weight will be 400,000 pounds, or 200 tons.

It will be able to carry 650 passengers, with plenty of baggage, across the Atlantic nonstop, or across the Pacific with one stop. Or it can carry a 60-ton Sherman tank, or two medium tanks, or three light tanks. It could take 400 soldiers with five tons of ammunition and equipment across the ocean and bring back 350 wounded with 40 or 50 nurses and doctors. *(Continued)*



WING SPAN is longer than a football field, and thickness at the hull is 13 feet. In this factory scene, expert cabinetmakers have the wing almost finished. One of the H-4's two pontoons also is shown.

The H-4 is the fruit of much dreaming and planning by Howard Hughes and Henry Kaiser, followed by a remarkable construction job now nearing completion at Culver City, Calif. They got together in 1942 on the plans for this ship, and started work on it late that year.

The plane is almost entirely constructed of wood strips, glued together. The metal in it, aside from the engines, is negligible. Skin and structural parts are built up of birch and spruce, layer on layer, formed into durable units by modern techniques and the use of new waterproof glues. Thinnest parts of the H-4 are $\frac{3}{64}$ of an inch, built up of three $\frac{1}{64}$ -inch veneers. The thickest part is ten inches, built of 200 veneers $\frac{1}{20}$ of an inch thick. The workers are mostly skilled cabinet-

makers, who know their wood and their glue.

Construction of wings and hull is virtually complete now. The next big job is to move them 22 miles to San Pedro Harbor, where a special graving dock and hangar are being

constructed at a cost of \$203,000. The moving job entails the removal of some 30 power lines and two buildings along the route.

The first flight of the big ship will take place some months hence. When Howard Hughes takes the controls for this flight, he will be sitting 24 feet above the water. The H-4 is not a speedy plane. Its climbing rate is 675 feet per minute, cruising speed 145 miles, ceiling 17,000 feet. Its tanks will hold 14,000 gallons of gasoline. It requires a run of 5,600 feet to obtain a speed of 86 m.p.h. for the take-off, and this takes 67 seconds.

EACH PONTON is taller than a man. Mounted on two such floats and the high, deep struts, the wings would clear a two-story building with room to spare.

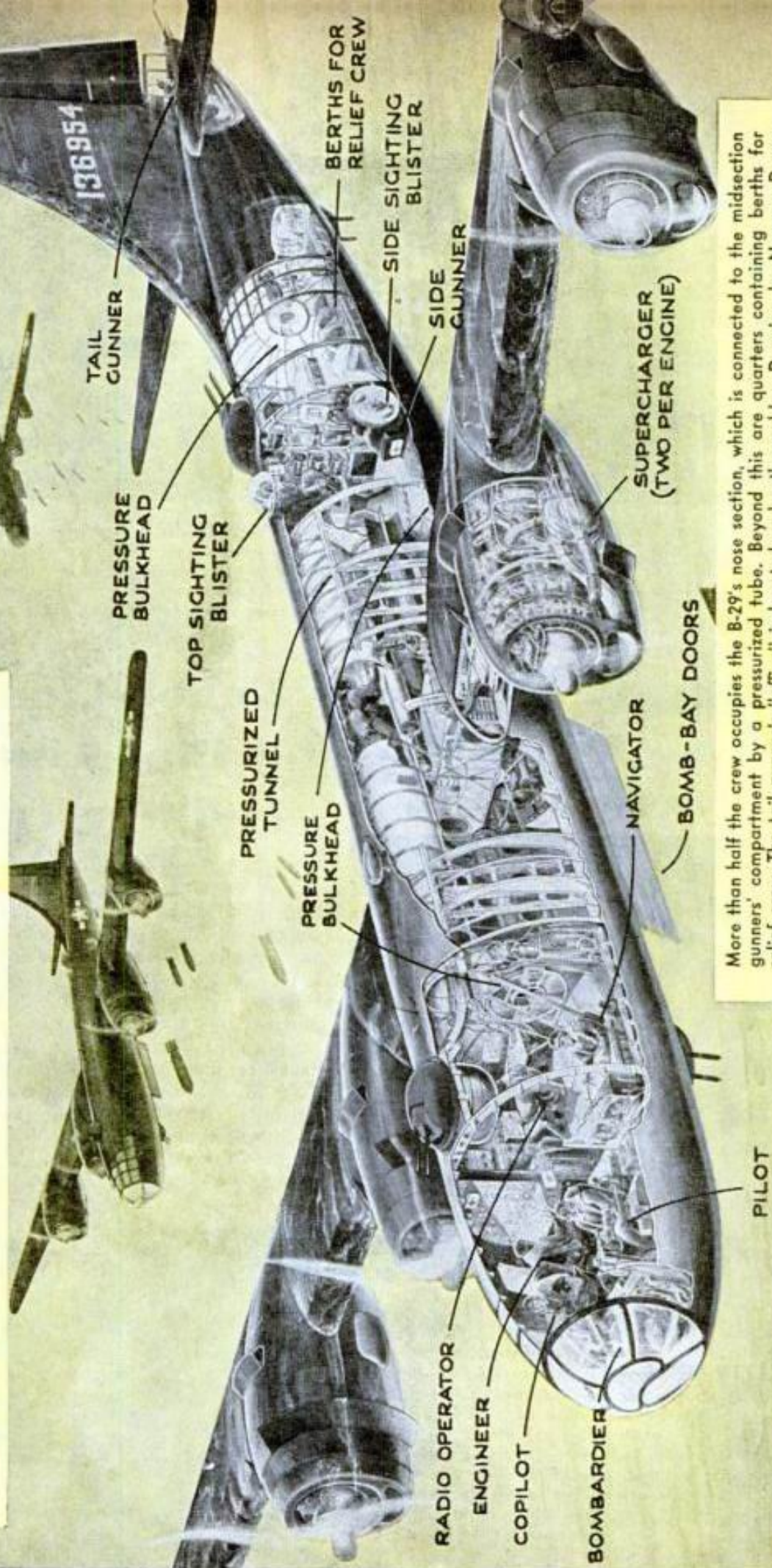


Your Pin-Up

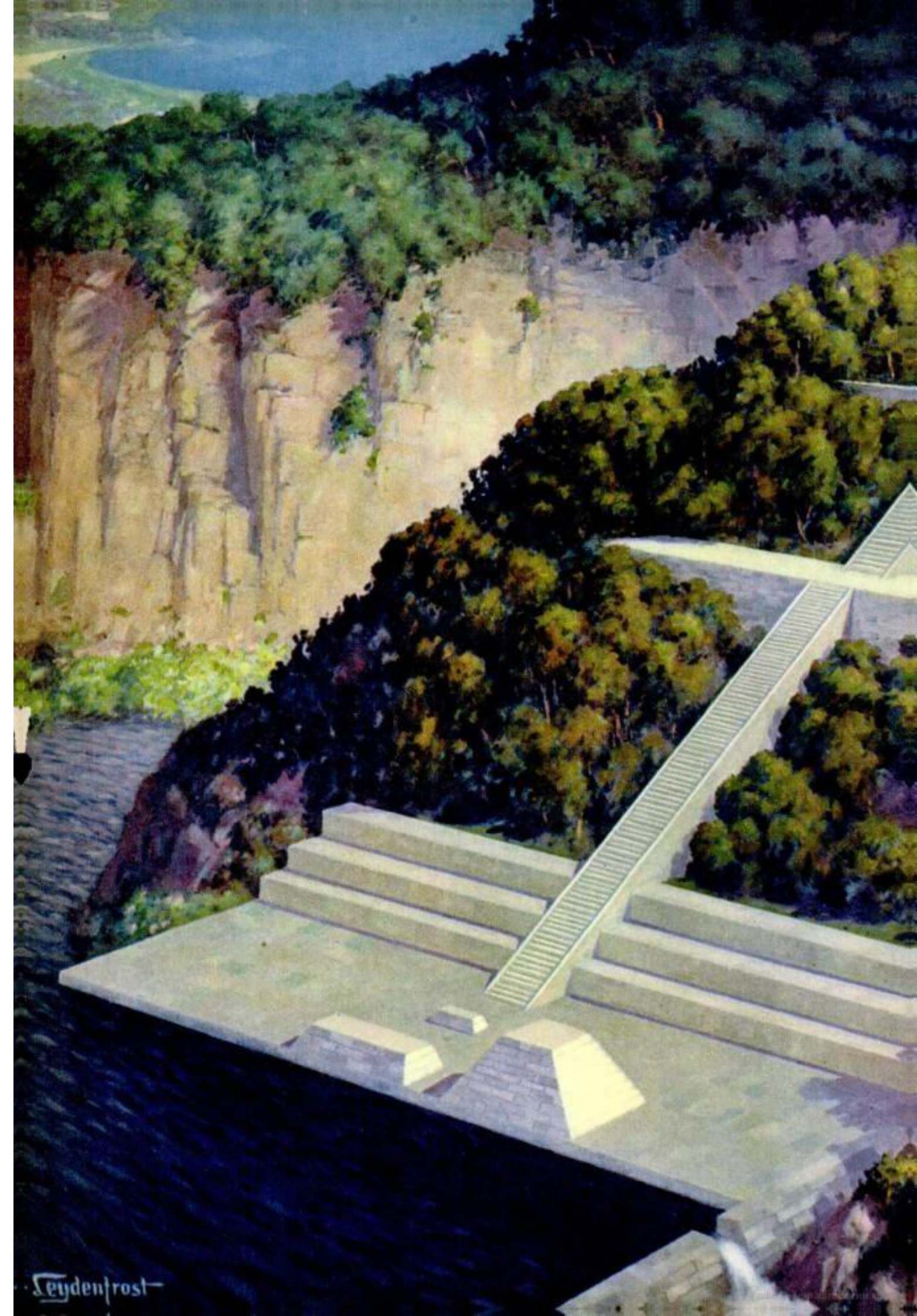
GRUMMAN F7F TIGERCAT NAVY FIGHTER. With twice the power of the famous Hellcat and 50 percent more weight, this twin-engine ship is described as the most powerful fighter-bomber yet produced for the Navy. First Navy fighter to have twin engines, it is powered by two 2,100-hp. Pratt & Whitney Double Wasps that put it in the 425-m.p.h. class and give it a mile-a-minute climb. It can carry two tons of bombs, a full-size marine torpedo, or any desired combination of rockets and bombs. With heavier firepower than either the Hellcat or the Corsair, it can smash even a bomber with a single burst. A two-place model is being made for night fighting. First production goes to the Marines; later, Tigercats will fly from our 45,000-ton carriers of the new Midway class.

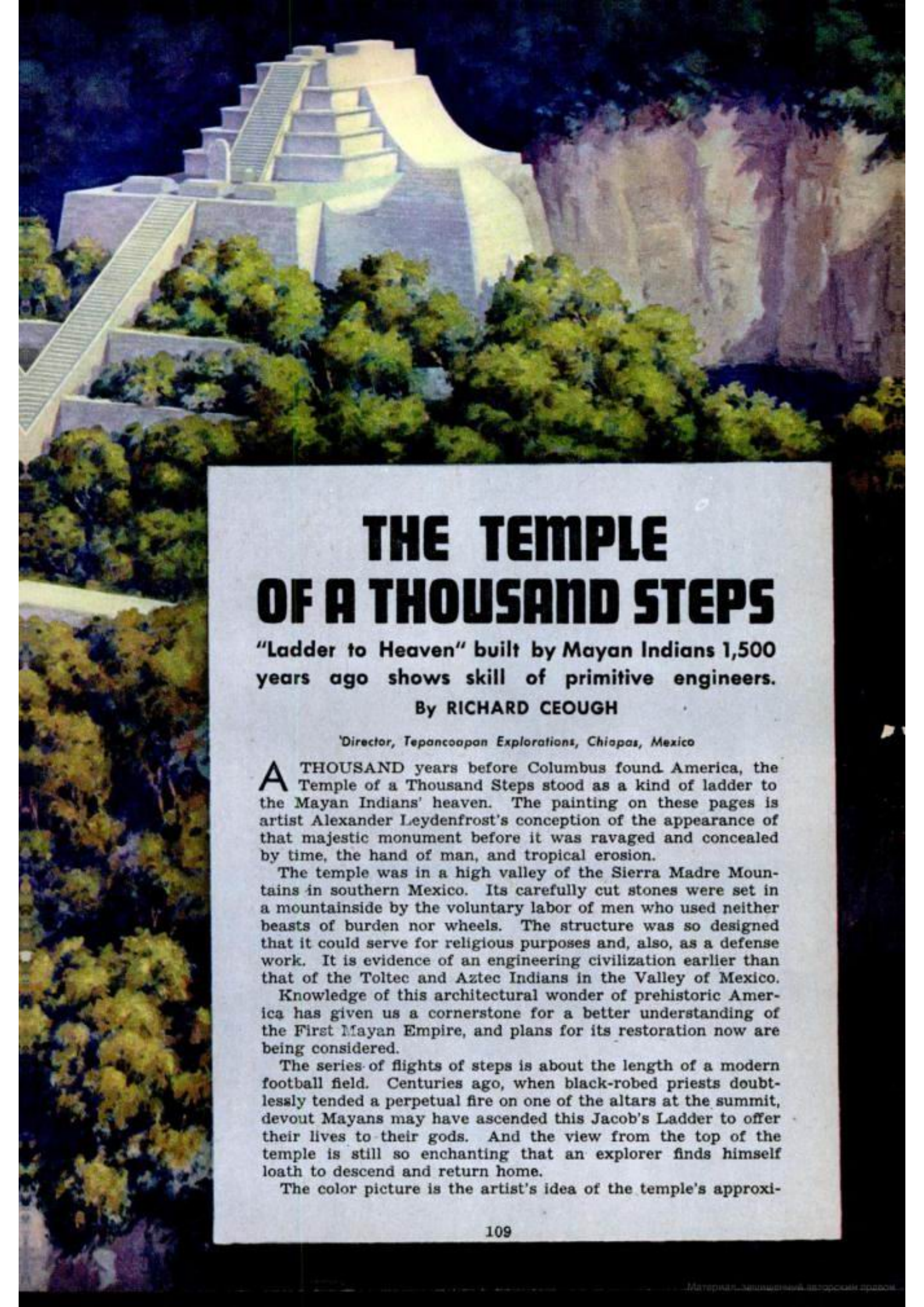
Inside the Superfortress

THE MIGHTY BOEING BOMBER — BATTLESHIP OF THE AIR — COMFORTABLY HOUSES CREW OF 11 IN PRESSURIZED CABINS.



More than half the crew occupies the B-29's nose section, which is connected to the midsection gunners' compartment by a pressurized tube. Beyond this are quarters containing berths for relief crew. The tail gunner's "office" is located under the rudder. Drawing by Norman Dawn.





THE TEMPLE OF A THOUSAND STEPS

"Ladder to Heaven" built by Mayan Indians 1,500 years ago shows skill of primitive engineers.

By RICHARD CEOUGH

Director, Tepancoapan Explorations, Chiapas, Mexico

A THOUSAND years before Columbus found America, the Temple of a Thousand Steps stood as a kind of ladder to the Mayan Indians' heaven. The painting on these pages is artist Alexander Leydenfrost's conception of the appearance of that majestic monument before it was ravaged and concealed by time, the hand of man, and tropical erosion.

The temple was in a high valley of the Sierra Madre Mountains in southern Mexico. Its carefully cut stones were set in a mountainside by the voluntary labor of men who used neither beasts of burden nor wheels. The structure was so designed that it could serve for religious purposes and, also, as a defense work. It is evidence of an engineering civilization earlier than that of the Toltec and Aztec Indians in the Valley of Mexico.

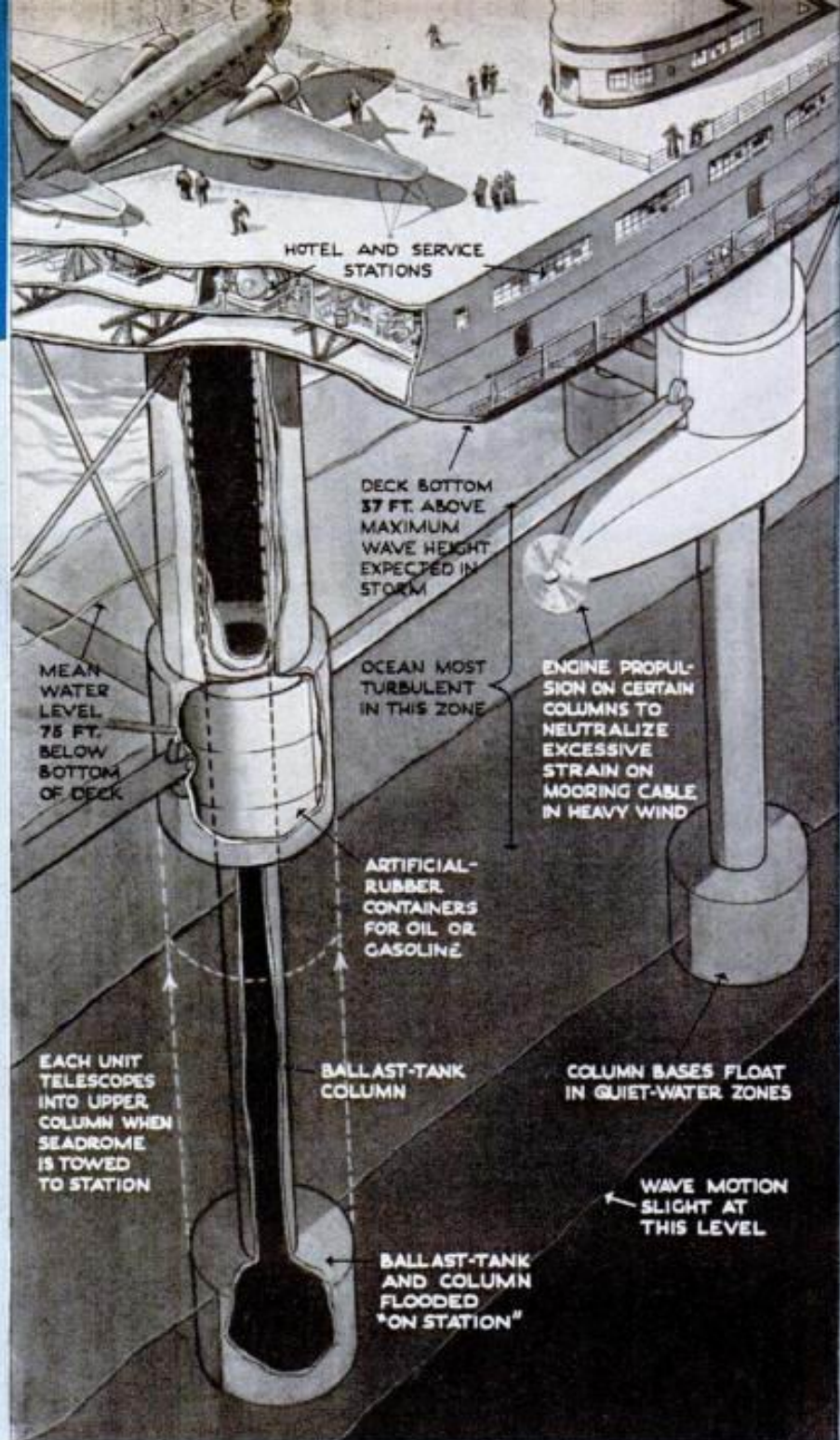
Knowledge of this architectural wonder of prehistoric America has given us a cornerstone for a better understanding of the First Mayan Empire, and plans for its restoration now are being considered.

The series of flights of steps is about the length of a modern football field. Centuries ago, when black-robed priests doubtlessly tended a perpetual fire on one of the altars at the summit, devout Mayans may have ascended this Jacob's Ladder to offer their lives to their gods. And the view from the top of the temple is still so enchanting that an explorer finds himself loath to descend and return home.

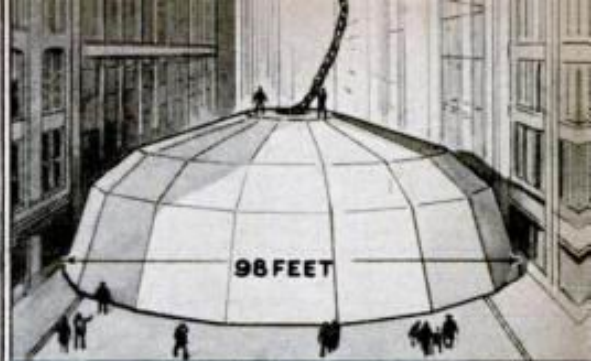
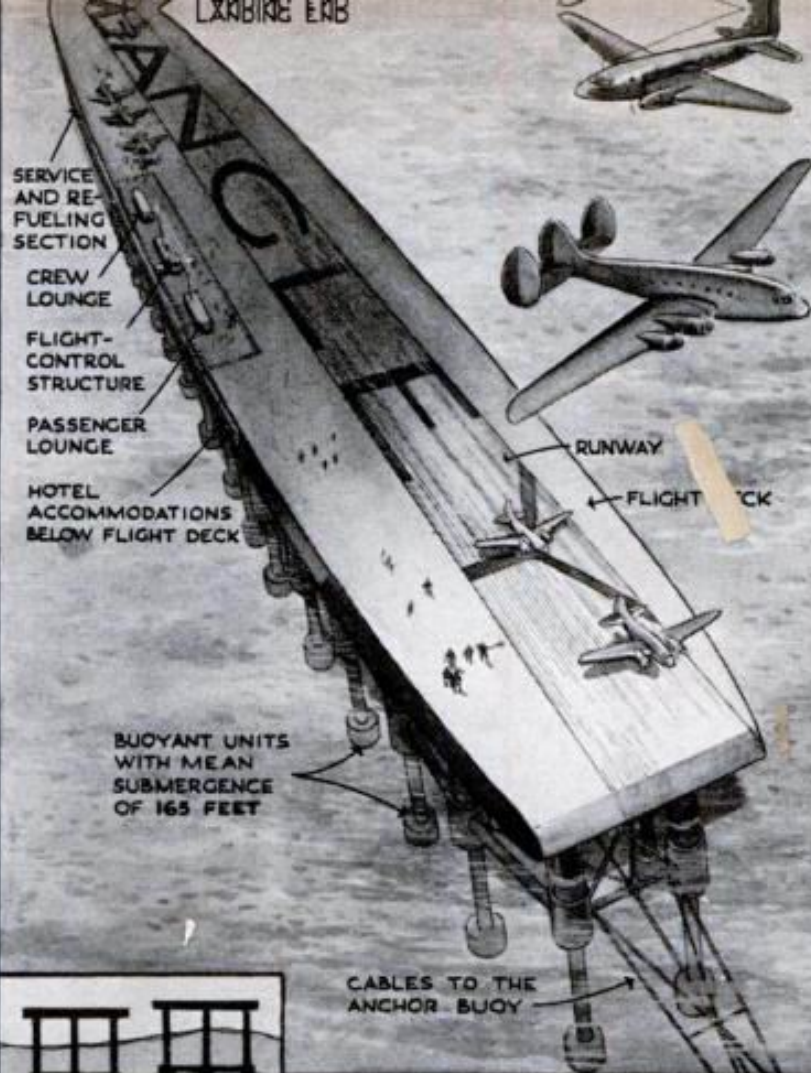
The color picture is the artist's idea of the temple's approxi-

SEADROME DESIGN IMPROVED

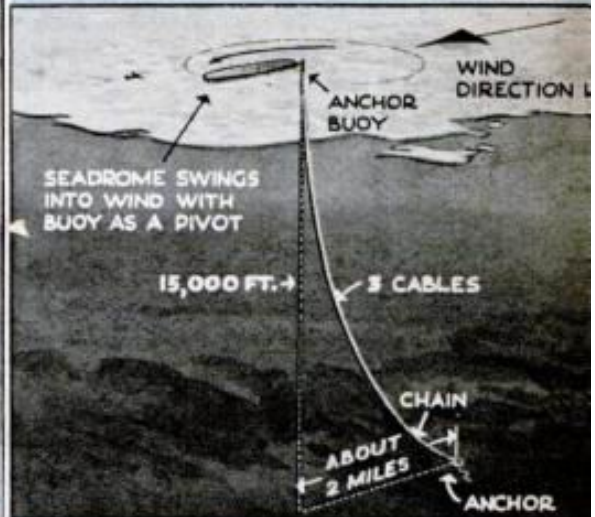
MODIFICATIONS in the design for postwar construction by Pennsylvania-Central Airlines of floating airports (P.S.M., Sept. '43, p. 81), which will dot the Atlantic to facilitate air travel between the east coast of the United States and European and African ports, have been announced by the designer of the seadromes, Edward R. Armstrong, of Philadelphia. Greater streamlining, both above and below the ocean's surface, will reduce air and water resistance and thus relieve tension on the airport's anchor cable. The flight deck will be slightly corrugated for better traction, and will carry counter-sunk lights to guide planes in night landings. There will also be less superstructure than was formerly planned, with most of the airport's housing sections placed below the flight deck. Another innovation will be the use of parts of the supports for storing oil, gasoline, and water. The airports will be 3,550 feet long and 400 feet wide, with only 150 feet of the width being used for the runway. Each seadrome will cost \$10,000,000 and will be named after one of the pioneers in the development of aviation.



EARLY SCULPTURE. This 20-ton basalt head was unearthed near La Venta, Tabasco, Mexico, by the National Geographic Society—Smithsonian Institution Archeological Expedition. Dr. Matthew W. Stirling (left), leader of the expedition, points out details of the head to Dr. Gilbert Grosvenor, president of the Society (center), and Dr. Alexander Wetmore, assistant secretary of the Smithsonian. The head is believed to have been carved about 1,300 years ago and to have been used in religious rites. It is now on exhibit in Washington, D. C.



How one of the 1,500-ton anchors would appear if it were placed in a city street



Each seadrome will swing from a buoy held by cables to an anchor on the ocean bottom



On short supports, airport would rise and fall with waves



Supports that reach to stable-water levels are required to hold airport steady

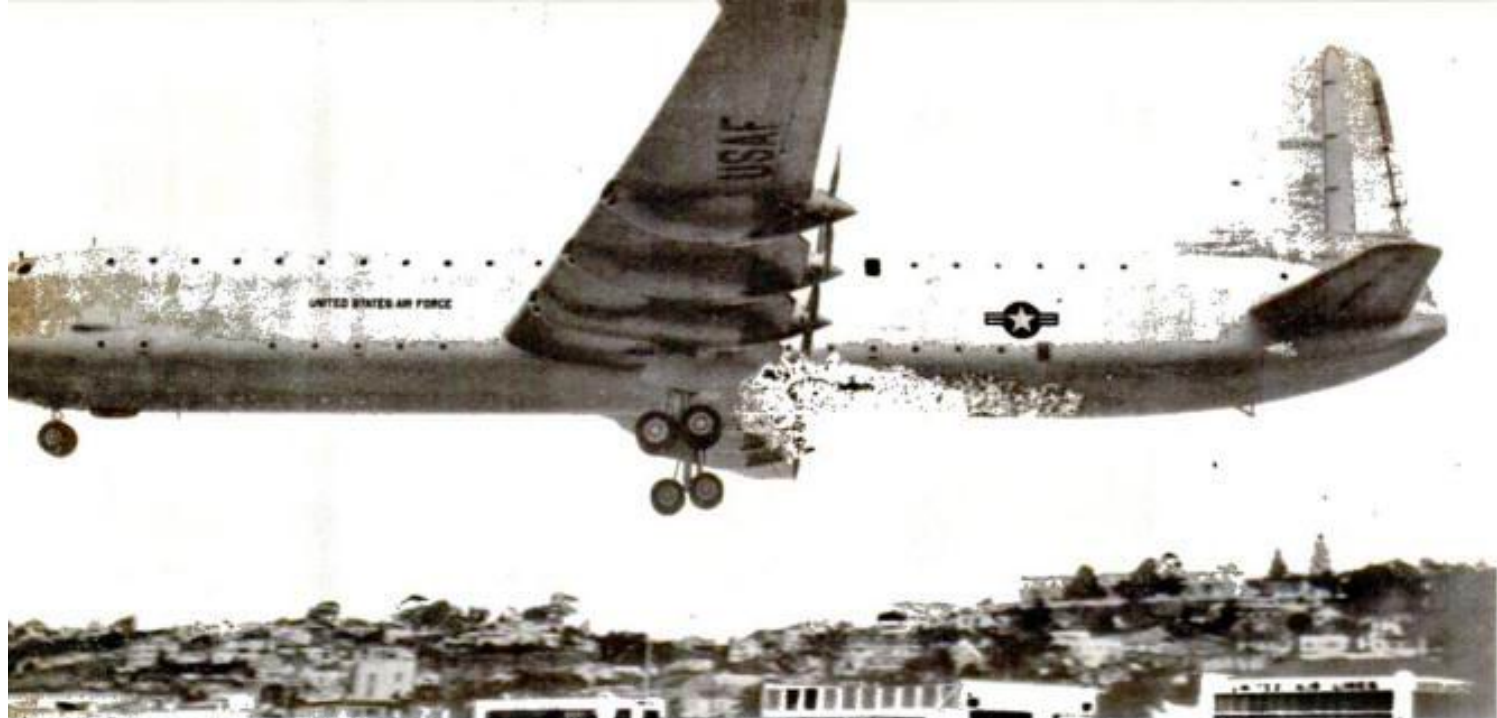


Airports will be spotted across the Atlantic at intervals of between 575 and 1,200 miles. Being able to refuel at each stop, planes will carry less gas and much greater passenger and freight payloads. Rates for the fastest crossings are expected to be six cents a mile

A FISH PIPELINE that sucks up a ton and a quarter of fish per minute from the hold of a boat is being used to bring ashore the catches made by the sardine fleet operating out of Portland, Me. An eight-inch hose takes the fish from the hold, which is flooded with water to prevent damage to the catch. A 12-inch hose then carries the sardines into the cannery, a screen separating water and fish just before they reach the bins. This new method, invented by John D. Toft, is said to have speeded up the unloading of the boats by 600 percent.

FEBRUARY, 1944





Champion aerial weight-lifter, the XC-99 can tote 50-ton payloads at speeds over 300 m.p.h.

Biggest Air Freighter

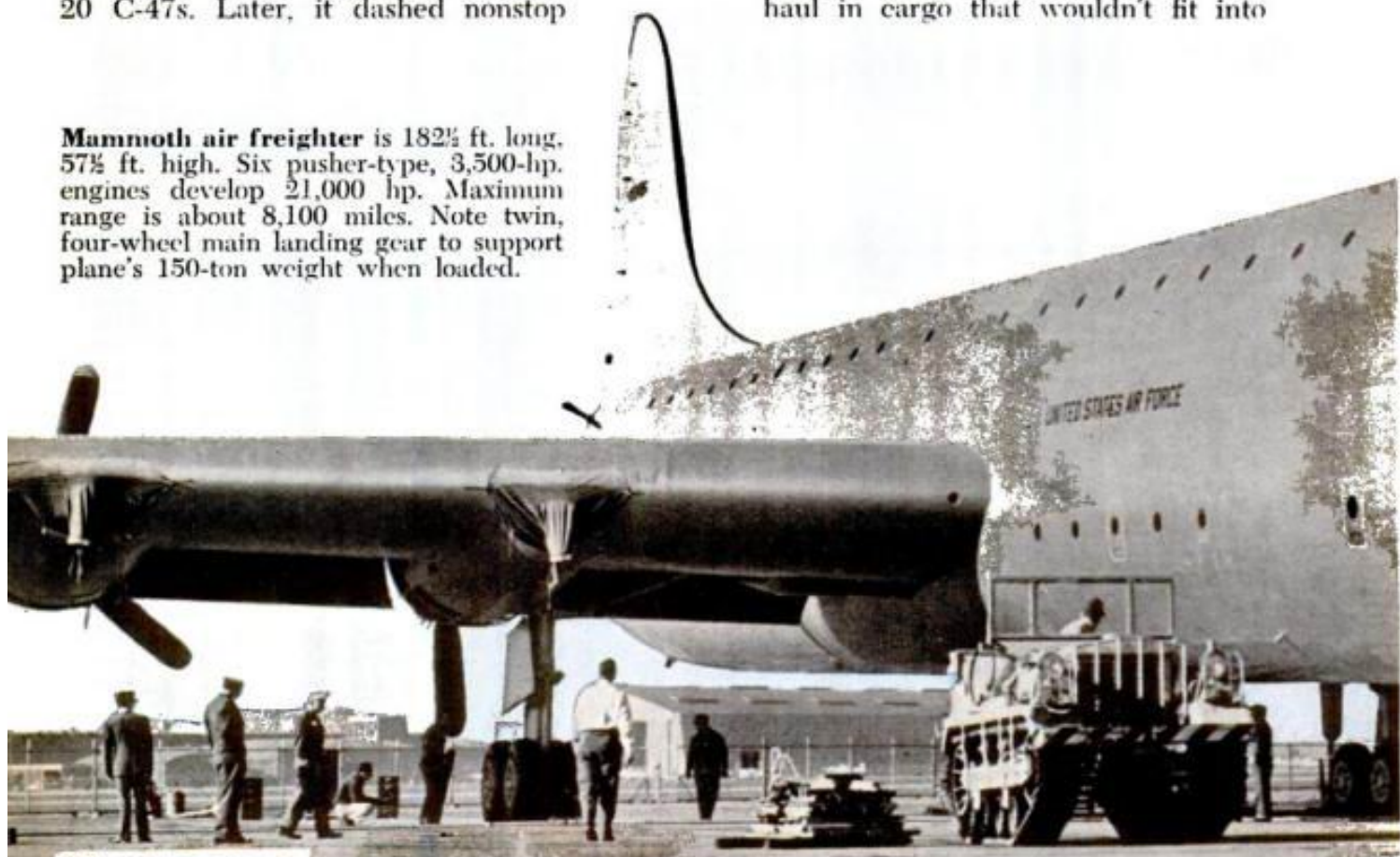
THE world's largest land plane has joined the war effort. Currently undergoing weight-lifting tests by the Air Force, the huge, experimental XC-99 is also making itself useful by ferrying critically needed military supplies to coastal jump-off points.

On one test hop it lugged 50 tons of aircraft parts from California to Texas—more cargo than could be carried by 20 C-47s. Later, it dashed nonstop

from California to Georgia with 42½ tons—largest transcontinental payload ever carried.

Big sister to the A-bomb-toting B-36, the mammoth Convair cargo plane has the same 230-foot wingspan, but is 20 feet longer and 11 higher. Its twin decks have a total cargo capacity of 30,000 cubic feet—as much as 10 railroad boxcars. Powered hoists at two giant hatches, fore and aft of the wing, haul in cargo that wouldn't fit into

Mammoth air freighter is 182½ ft. long, 57½ ft. high. Six pusher-type, 3,500-hp. engines develop 21,000 hp. Maximum range is about 8,100 miles. Note twin, four-wheel main landing gear to support plane's 150-ton weight when loaded.



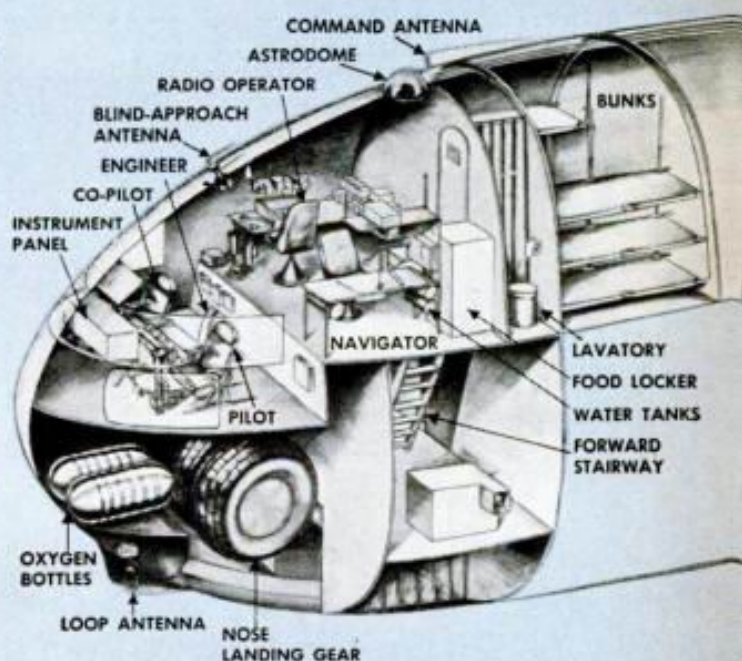


Powered hoists haul large, heavy cargo aboard XC-99 through two big hatches like one above.

Goes to War

another plane. With ramps in place, jeeps, trucks, and heavy guns can be rolled right in. Inside, cargo is speedily stowed by monorails that run the full length of both decks.

As a troop transport, the plane can carry 400 fully equipped soldiers or 305 litter patients. The U. S. Post Office is also eyeing the giant as a possible mail carrier. Besides toting 50 tons at a clip, it could provide full facilities for sorting mail en route.



Compact arrangement of flight controls and crew quarters in nose leaves rest of plane free for cargo. Note that engineer sits near pilots, reading same instruments to avoid duplication.



INSTRUMENT LANDINGS

Bad-weather landings are safer at Dulles. Incoming aircraft's navigation receiver picks up glide-slope and localizer signal 7 to 10 miles out. Narrow beams sent by ground transmitters cause pointers on gauge (right) to center when plane is on course. Pilot steers to keep them centered. Dulles has Instrument Landing System transmitters on two runways, plus Precision Approach Radar, which gives pilot radio directions from ground controller. Many large airports have only one ILS. Few have PAR.



THE TOWER

From here, controllers direct planes toward the runways by radio. They give approval to land or take off. The bubble on top of the tower "paints" a radar picture of the runways so the controllers can see the ground even in dense fog.



Dulles airport, 27 miles out of Washington, D. C., has more of everything—and all brand-new. It was built to handle the volume of traffic expected in the '70s, including supersonic airliners—and is better equipped to handle them than any other air terminal now in existence. Experts agree it's the airport of tomorrow—here today.

It has "more of everything";
that's why pilots say it's the

WORLD'S SAFEST AIRPORT



CRASH CREWS

Hopefully, these rarely will be needed. Trucks are positioned so they can reach the runways in seconds. Pumpers, custom-built to fight plane fires, are the world's largest.

VASI LIGHTS

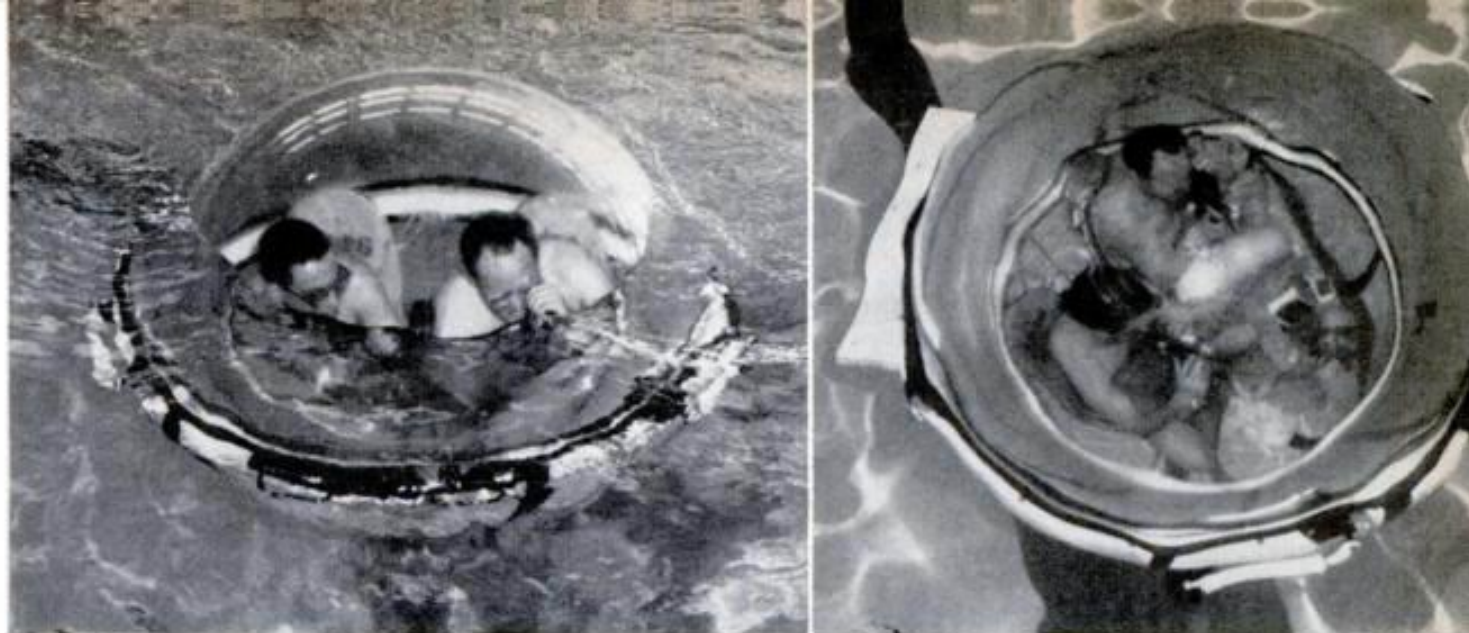
Visual Approach Slope Indicator lights, aviation's newest landing aids, are installed on 10,000-foot runway. Pilot sees red, red-and-white, or white, according to his altitude. Correct blend of red-and-white means plane is approaching at proper angle. The lights are always visible.



RUNWAY LIGHTS

Center-line runway lights let pilots land on the "dotted line." The lights, bedded in concrete, also trace taxiing route.

CONTINUED



China Lake, Calif., water-test a 56-inch Plexiglas prototype of two-man submarine cabin.

Sub for Undersea Adventure

How it began. Although the idea of using glass for submarines has cropped up a number of times, the practical concept, if it had a beginning, began with H. A. Perry of the suburban-Washington U.S. Naval Ordnance Laboratory. In 1963, Perry published a paper on "Feasibility of Transparent Hulls for Deep-Running Vehicles." In

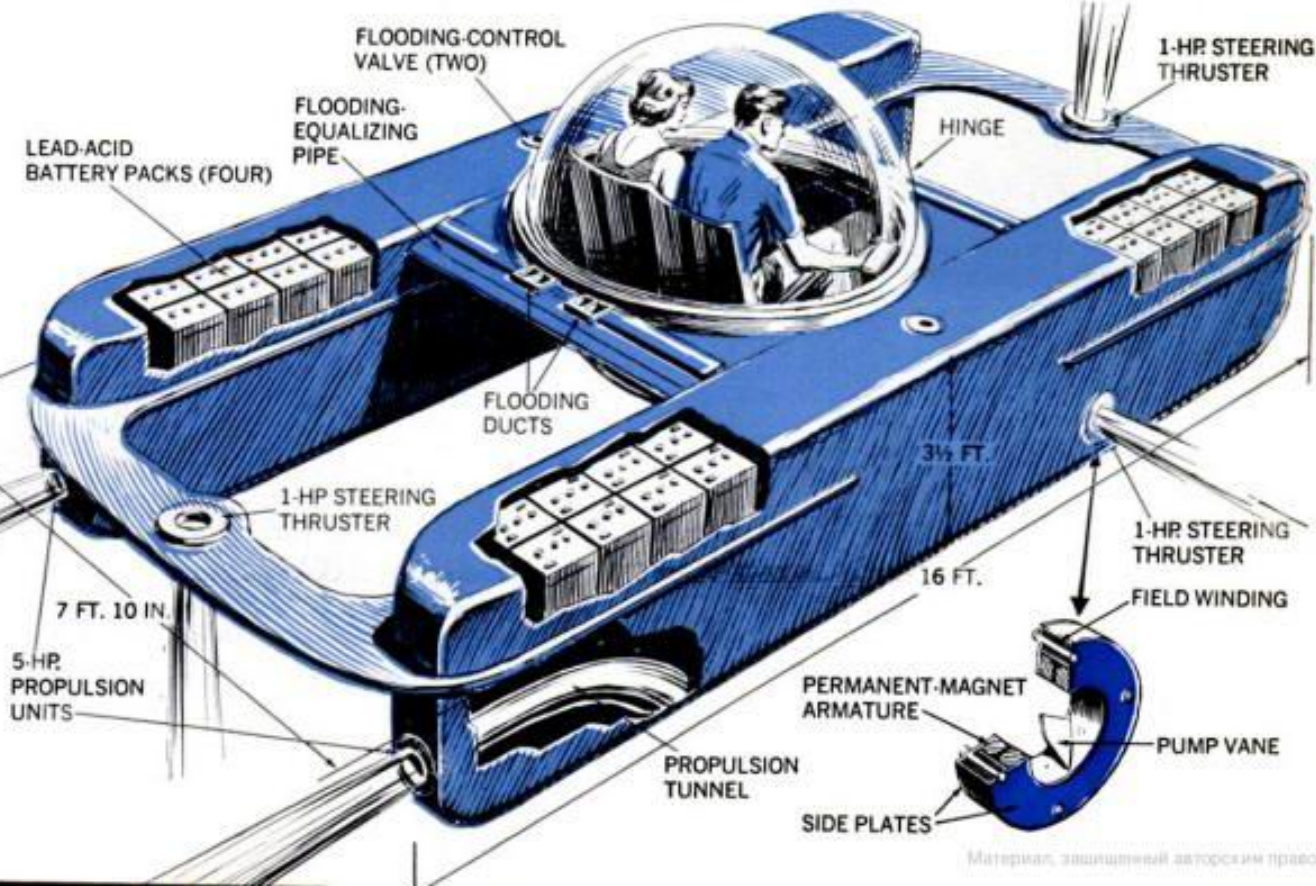
simple language, his theory was this: Glass owes its reputation for fragility to its poor fracture resistance under tension. This lack of fracture resistance is due to tiny surface flaws in the glass.

But the resistance of glass to compression, which determines the strength of a glass hull under pressure, Perry argued, is so

Continued

Simple construction makes it possible to build glass sub for well under \$10,000. The two fiberglass pontoons, open to the sea, contain all machinery except

photoelectric control box for signaling through glass hull and life-support system. In an emergency, the glass sphere can be released to float to the surface.





CLOSE CALL IN SILO 10

By James Joseph

THE voice from 60 feet underground—from Silo 10's Atlas missile-launch center—shot across the communications net:

"The bird won't nest . . . repeat . . . the missile has failed to nest. Keep your positions. Do not move."

The time was 7:35 p.m. The place: Silo 10, Dyess Air Force Base, near Abilene, Tex. For only the second time in the missile age, a fully fueled and flight-ready "bird"—an eight-story-high Atlas F ICBM, loaded with more than 30,000 gallons of volatile liquid oxygen (LOX) and kerosene-like RP-1 fuel—had jammed in its launching silo.

Moments later came more bad news: "TV scan cameras see no boil-off vent . . . the missile has apparently lost its GOX vent" (for gaseous oxygen).

The bird was set to explode.

The "book" said they should abandon the haywire missile, but they gambled their lives to save the giant bird and its nest

CONTINUED

Digging for Gold

It may be hotter in hell, but at 6,800 feet they're getting close—rock temperatures are 120 degrees

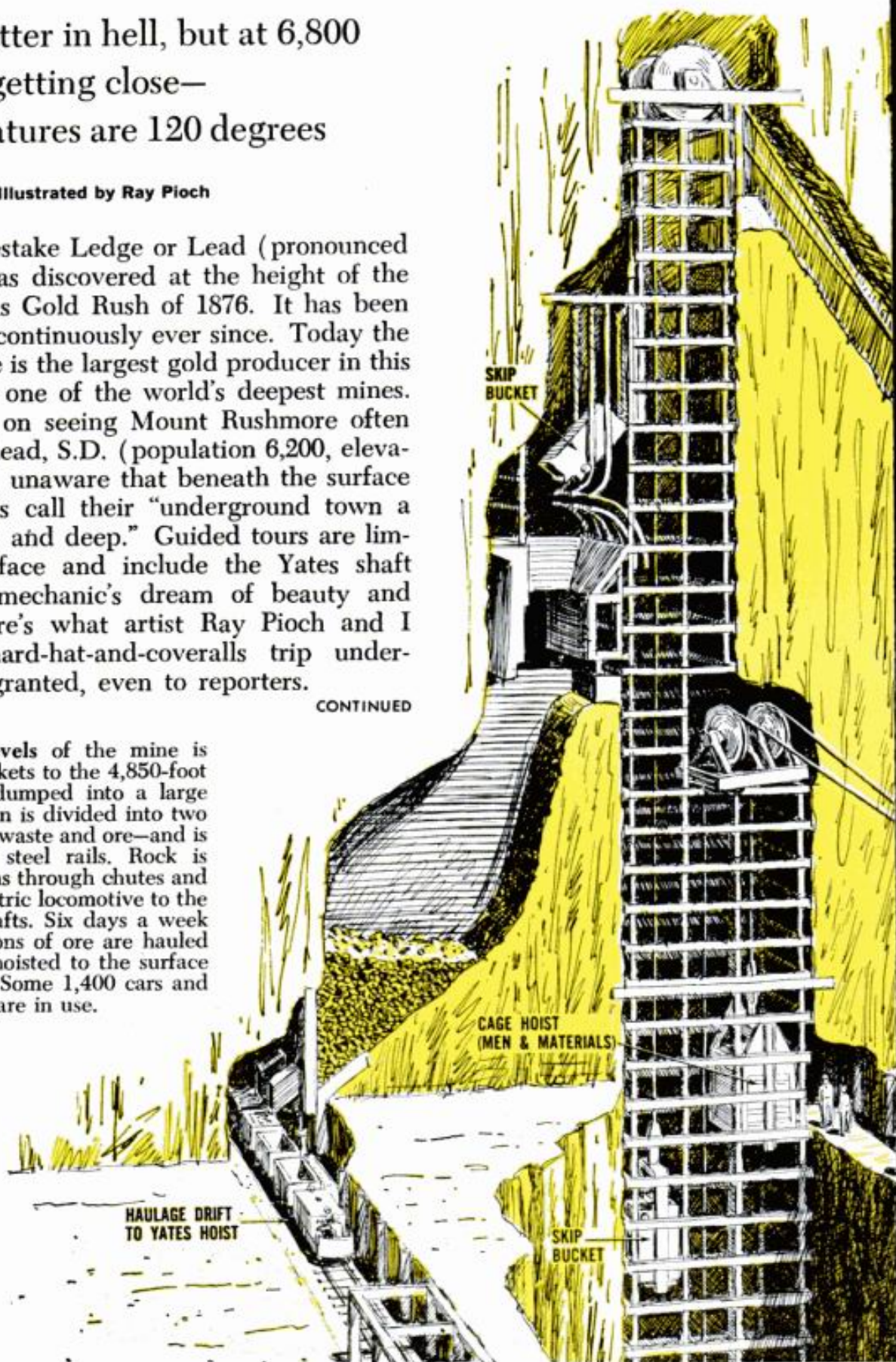
By Jim Liston Illustrated by Ray Pioch

THE Homestake Ledge or Lead (pronounced "leed") was discovered at the height of the Black Hills Gold Rush of 1876. It has been producing gold continuously ever since. Today the Homestake mine is the largest gold producer in this hemisphere and one of the world's deepest mines.

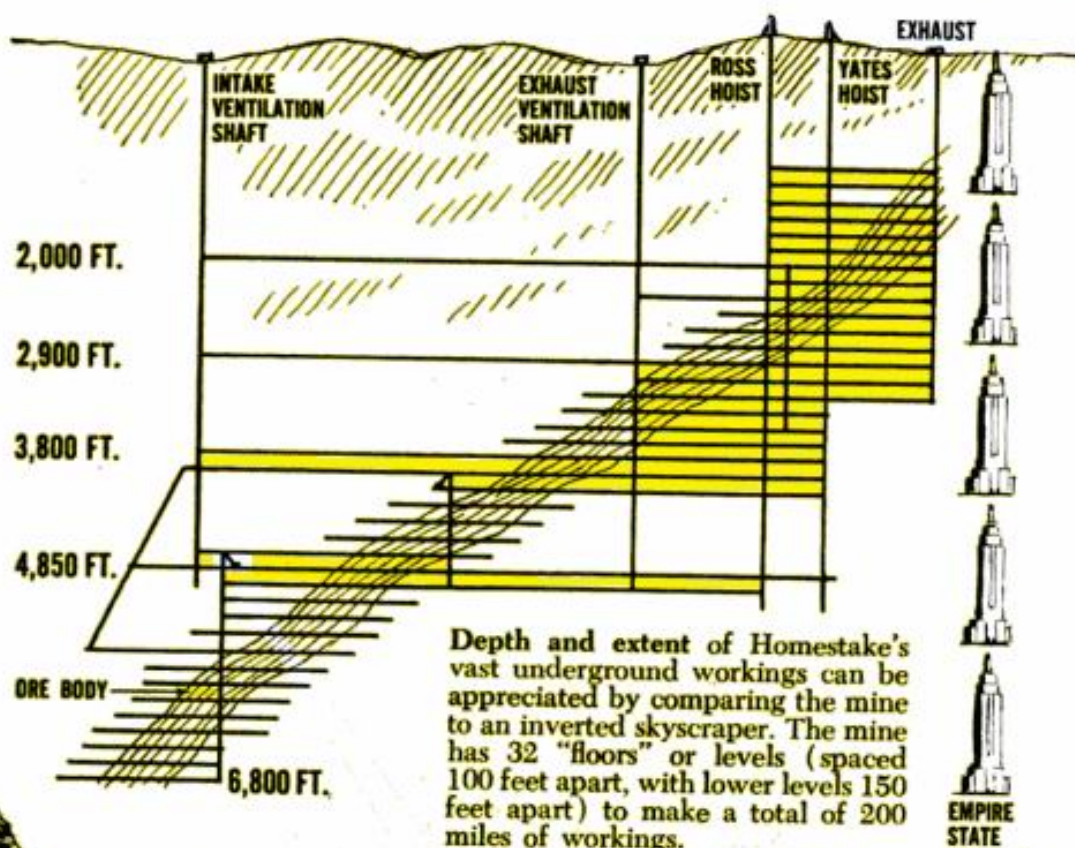
Tourists bent on seeing Mount Rushmore often hurry through Lead, S.D. (population 6,200, elevation 5,000 feet), unaware that beneath the surface lies what miners call their "underground town a mile high, wide, and deep." Guided tours are limited to the surface and include the Yates shaft hoist room, a mechanic's dream of beauty and power. But here's what artist Ray Pioch and I found on a hard-hat-and-coveralls trip underground, rarely granted, even to reporters.

CONTINUED

Ore from deep levels of the mine is hoisted in skip buckets to the 4,850-foot level where it is dumped into a large storage bin. The bin is divided into two compartments—for waste and ore—and is lined with heavy steel rails. Rock is drawn from the bins through chutes and transported by electric locomotive to the Yates and Ross shafts. Six days a week more than 6,500 tons of ore are hauled to the shafts and hoisted to the surface in eight-ton skips. Some 1,400 cars and 100 miles of track are in use.



Over One Mile Deep

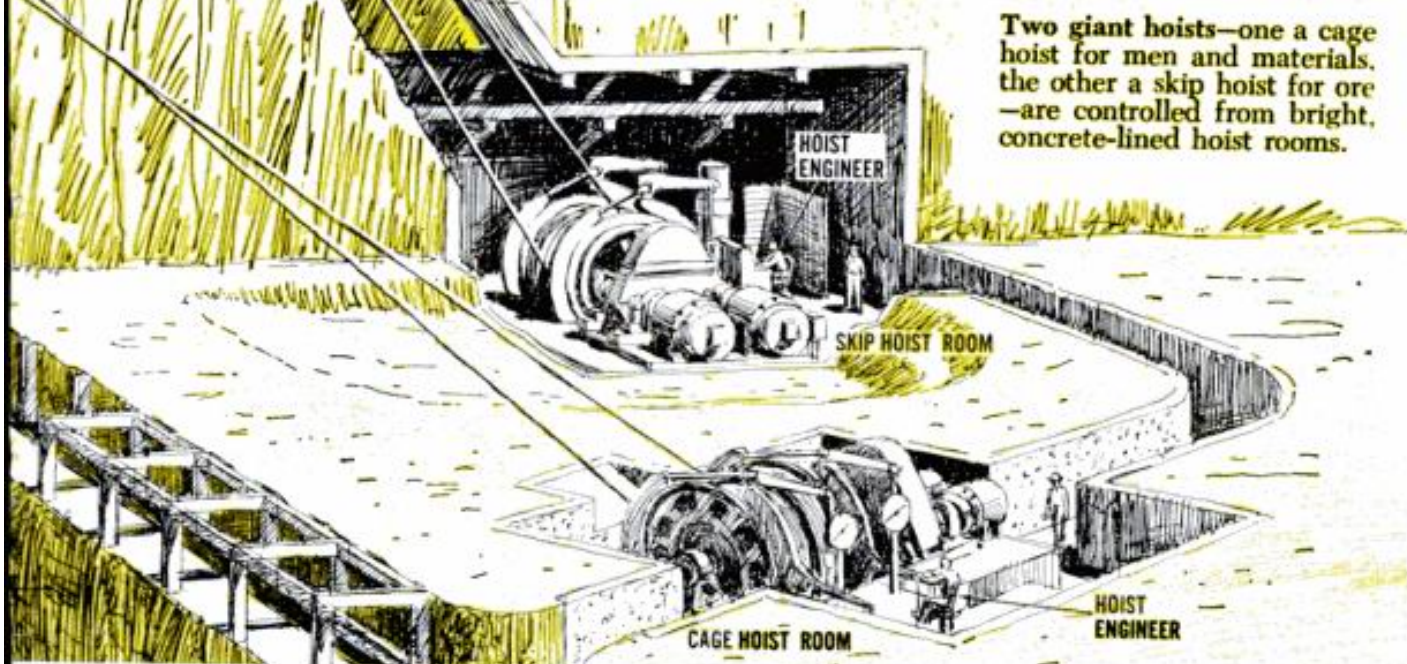


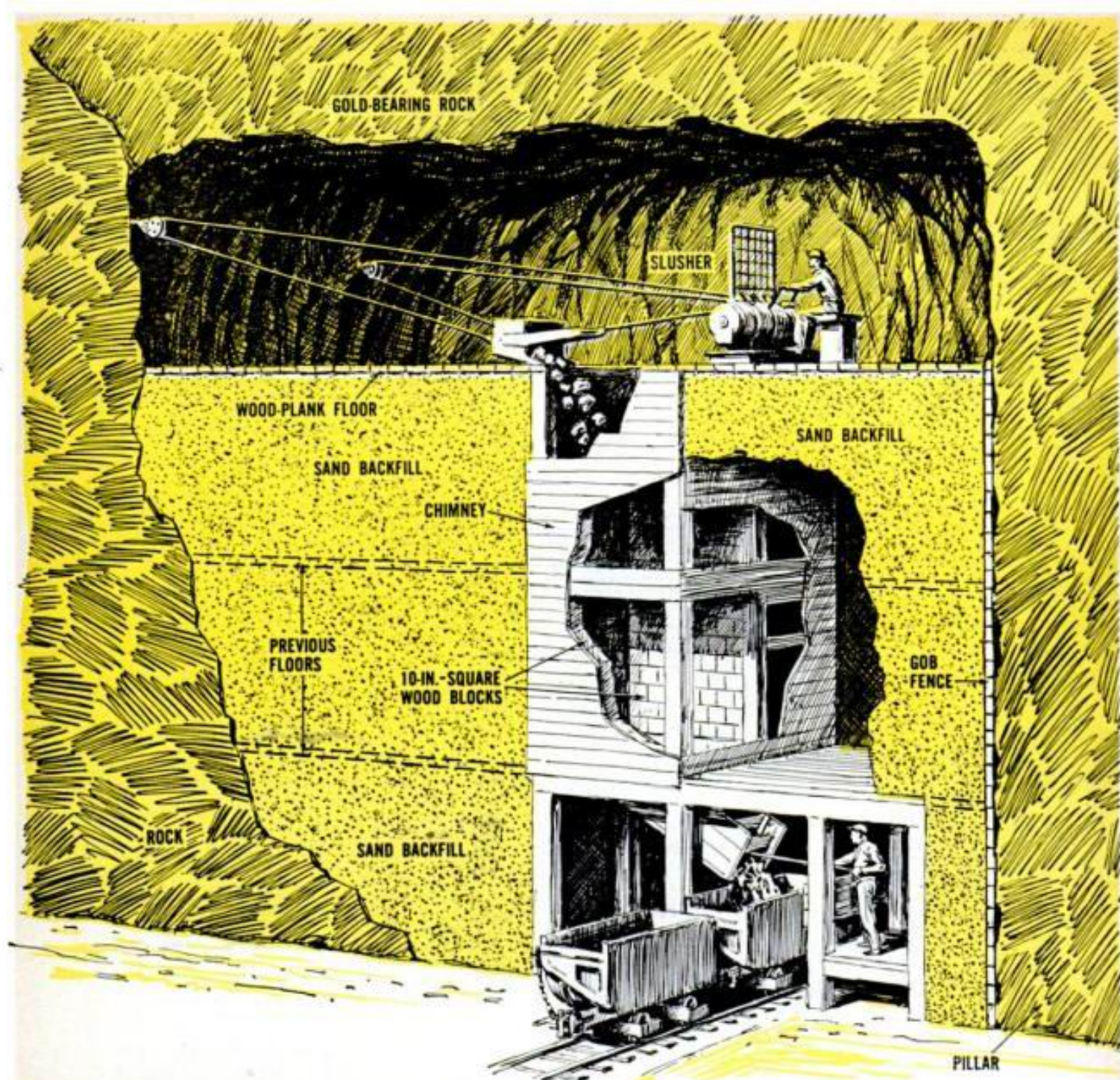
Arrow indicates location and size in relation to rest of mine of this

UNDERGROUND HOIST AT THE 4,850-FOOT LEVEL

Ross and Yates shafts (above) move men, ore, and materials between the surface and the 4,800-foot level. Miners ride a narrow-gauge railway to this second hoist, which takes them as deep as 6,800 feet where new tunnels follow the ore body.

Two giant hoists—one a cage hoist for men and materials, the other a skip hoist for ore—are controlled from bright, concrete-lined hoist rooms.



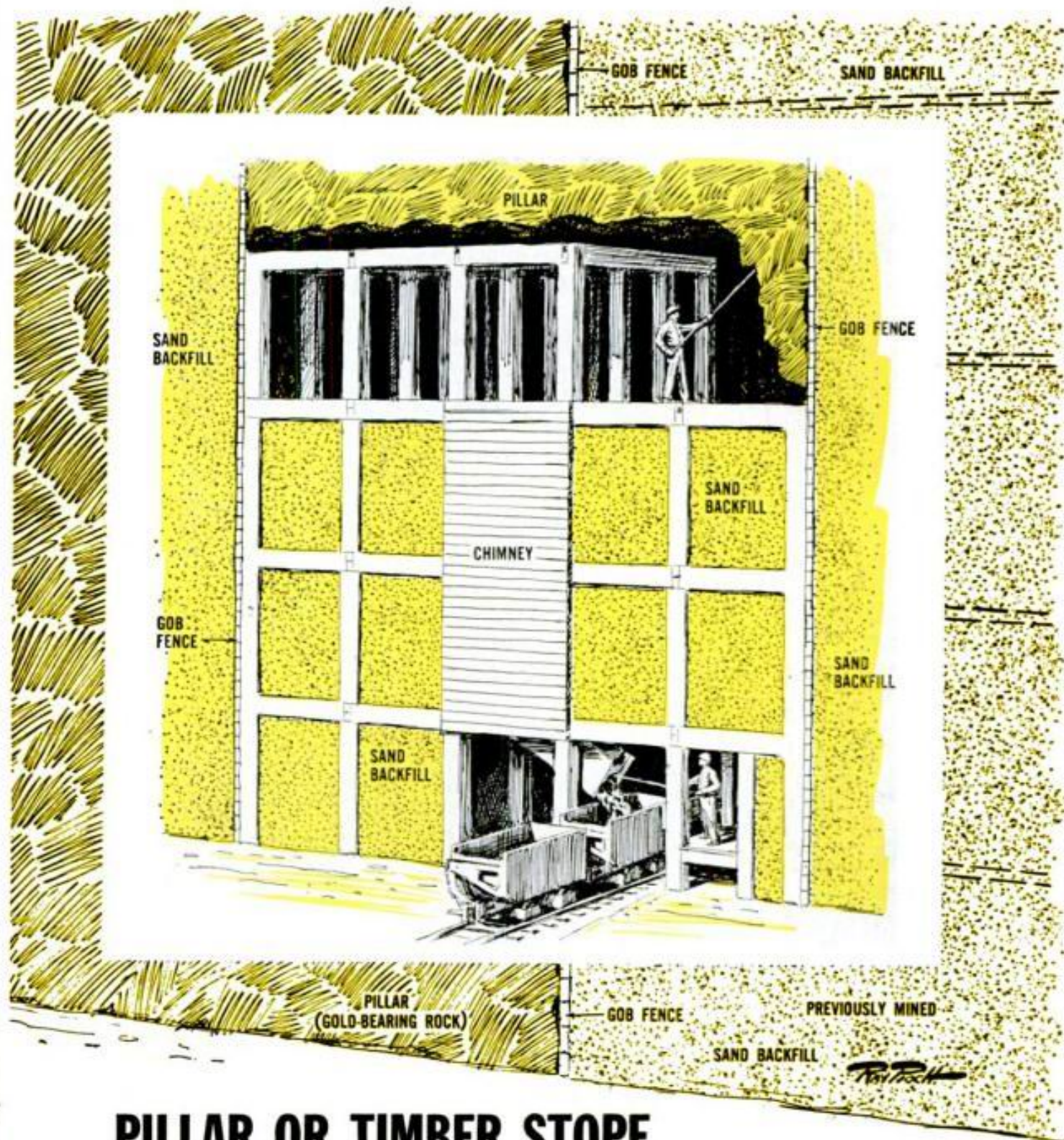


CUT-AND-FILL STOPE

ON EACH level of the mine the ore body is located by tunnels, called drifts. Ore is mined in a series of rooms (stopes), from one level up to the level above. Nearly all of it is mined by "cut-and-fill stoping." Using sand fill as a floor, miners work upward, drilling and blasting a new cut of ore 10 feet high. Broken ore is removed by scraping ("slushing") it into an ore pass to a chute on a level below, where it is loaded into cars.

After a slice of ore has been removed,

the space is filled with sand, obtained from tailings of the mill. This provides both support and a floor upon which the next slice is broken. The sand (mixed with water) is run in from the surface through rubber-lined pipe to the top of the stope. A gob fence is pinned to the adjoining gold-bearing pillar. This prevents sand from running out when that pillar is mined. In sketch above, a miner is testing the roof after previous blasting. Called "barring down," this is an important safety measure.



PILLAR OR TIMBER STOPE

AFTER cut-and-fill stopes have been mined out and backfilled, the pillars are mined with timbers, or square sets. Timber sets are made of 10-by-10s, but to lessen the danger of cave-in, each floor is sand-filled as it is mined.

Two sets of timber, called a chimney, are laced sand-tight with three-inch tongue-and-groove slabs for a hoistway, manway, and rock bin. The bin is lined

with 10-inch-by-10-inch wood blocks to withstand the rock that is slushed into it. Square-setting is costly but necessary to complete the mining of ore bodies with a minimum of risk.

Hard-rock mining is less hazardous than digging coal, and Homestake's 800 non-union miners, who work on individual contract, can average \$7,000 to \$8,000 a year.



Soft landing on the moon with aid of hover and landing retrorockets is depicted by artist.



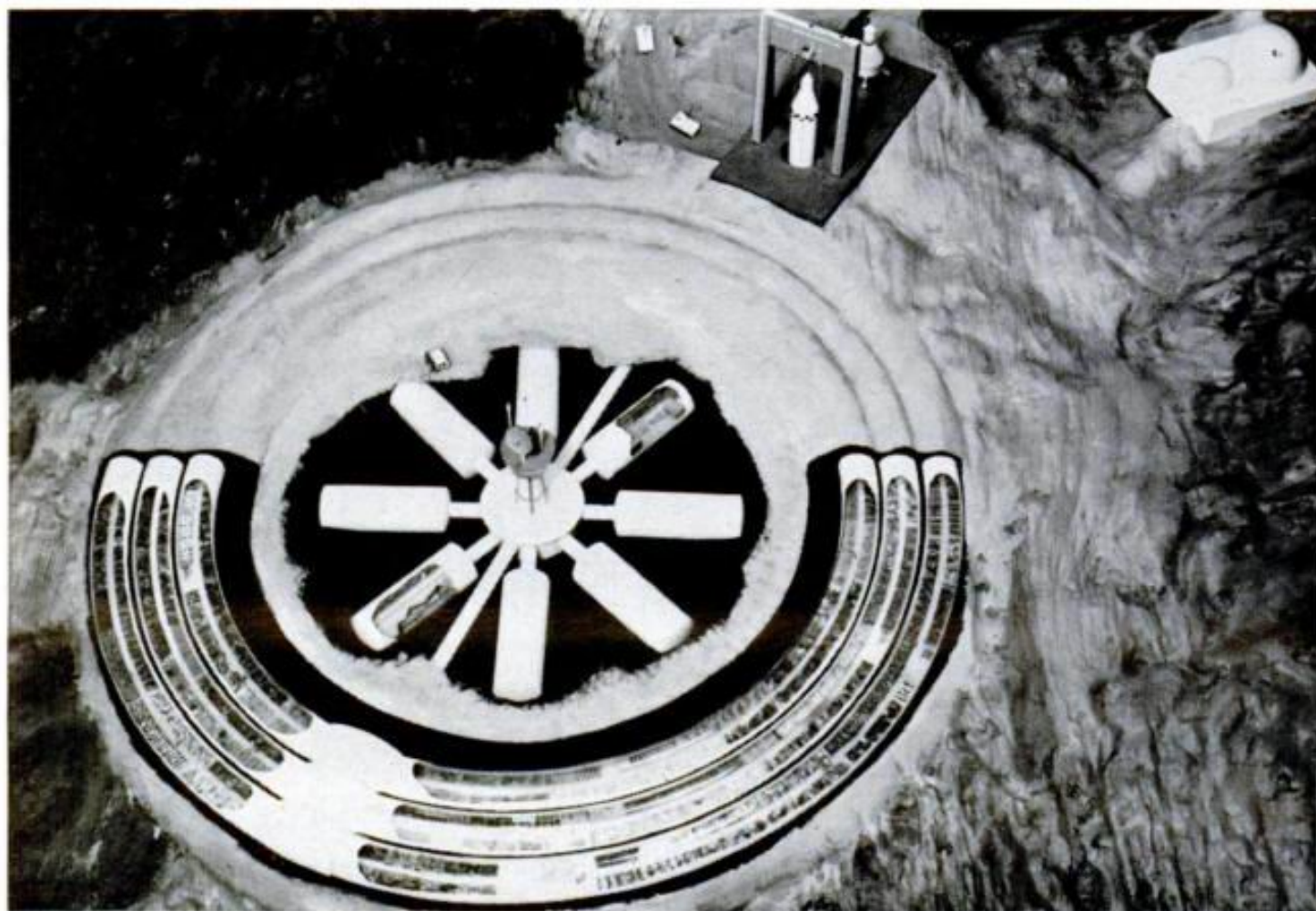
Nose cone opens wide, and robot rolls out, towing nuclear reactor that provides power.

Lunar housing for early arrivals

When man makes it to the moon, he'll need a place to live—and quick. Douglas Missile and Space Division proposes to send a robot on ahead to prepare a shelter for protection against meteoroids, radiation, and temperature extremes. The robot would be an all-purpose vehicle controlled by telemetry and monitored by television. It would land in a rocket nose that would

serve as the astronauts' earliest shelter. Its first job would be to set up a portable nuclear reactor for power and communications. Then, acting like an earthbound snow blower, it would scoot around the shelter, scooping up lunar soil and spraying it on the nose to bury it.

For later lunar explorers, North American Aviation's Space Systems Division



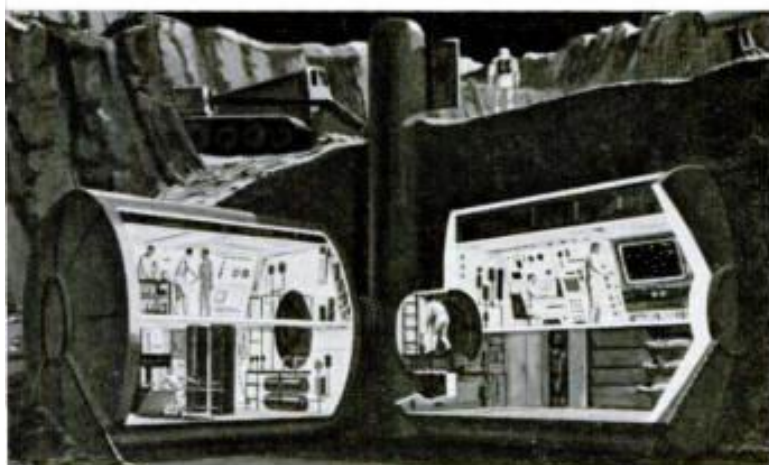
Wheel spokes in model above are empty booster tanks that serve as quarters for astronauts. Rim

of underground shelter contains enclosed oxygen converters and gardens to grow food.



Lunar soil is scooped up, blown over shelter. TV camera on tripod near spout monitors work.

visualizes a self-sufficient colony (below). It would be built from rocket-booster tanks radiating like the spokes of a wheel from a communications hub. They would contain living quarters, medical center, recreation areas, and shop facilities. Ringed around them would be enclosed gardens to provide food and to convert carbon dioxide into oxygen. A water-conversion plant would be set over a fissure from which volcanic rock would be mined through a vertical shaft, crushed, and heated to extract up to a gallon of water per cubic foot.



Cutaway of buried booster tanks shows how they may be arranged to care for explorers' needs.



Water-conversion plant covers a fissure from which volcanic rock may be processed for water.



Water jet swivels to steer no-prop, no-rudder, shallow-draft experimental boat.

Wankel rotary engine pushes these new boats

The Wankel rotary engine [PS, Mar. '60] has finally found practical use—but not in a car. A 43-hp. version powers the Swiss experimental jet boat above. Pumps suck up water from the underside, exhaust it under pressure.

A smaller 21-hp. Wankel engine pushes the Ski-Craft below, a German water-skiing device, at up to 27 m.p.h. The Ski-Craft will be sold by Transcontinental Motors in New York for over \$1,000. A larger Wankel will appear this fall in a German NSU car.



Ski-Craft has grab handles attached to control box. A gallon of fuel lasts an hour.

Inside the World's First Pushbutton Prison

By Charles Remsberg Illustrated by Ray Ploch

SOME 700 of the toughest convicts in the U. S. will begin filing into a cluster of split-level buildings next fall to become residents of the world's newest penitentiary. The \$10,000,000 jail, set on a 1,250-acre tract in the wooded hills of the Crab Orchard National Wildlife Refuge near Marion, Ill., will be the most internally televised, electronics-oriented prison ever built.

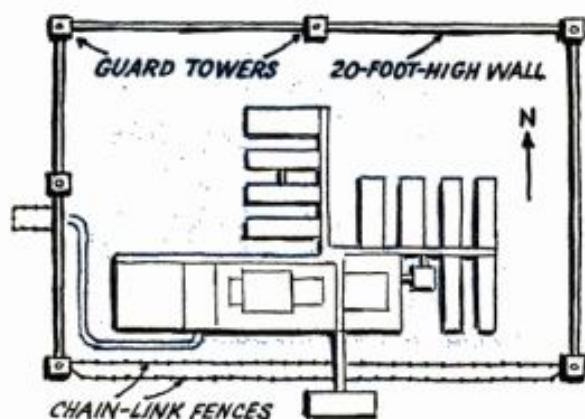
The traditional vertically barred windows will be absent. In the shaded courtyard around the circular chapel (with an altar that revolves to permit both Catholic and Protestant services) will be a reflecting pond and shrub-

CONTINUED





Six guard towers, 35 feet high, are located atop outside walls. They are connected by intercom to both control and message centers.



Plan view shows the placement of walls, double-link chain fence, and guard towers in relation to various penitentiary buildings. These all interlock for maximum exterior security.

bery. Opening off the library will be two secluded patios for reading and relaxation.

But the open appearance will be deceptive.

More than brick and steel. U. S. Bureau of Prisons officials are depending on science to make Marion the world's hardest place to get out of.

Designed by St. Louis Architects Hellmuth, Obata and Kassabaum with security foremost in mind, Marion's 15 main buildings are arranged along four corridors that radiate from a central core. Each corridor runs midway between the floors of the two-story buildings, allowing easy access to either level—and making Marion the first split-level prison. Any part of this complex can be reached without stepping outdoors, but anyone going from one wing to another must pass through the hub of the corridors.

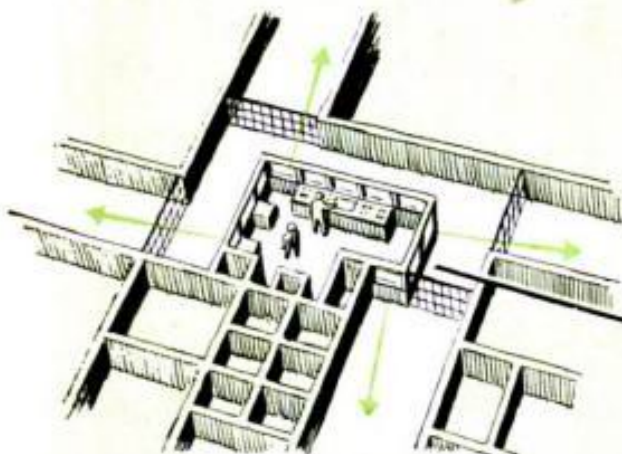
This pinwheel plan makes surveillance easy. Guards standing behind plate-glass windows in the bulletproof control center at the hub can scan the full length of each hallway by moving only a few inches. Other guards, manning a glass-enclosed message center atop the prison's administration building, can keep a similar close tab over the roof tops.

The control and message rooms, in fact, will be the nerve centers of the entire penitentiary. Like airport control towers, they will monitor and direct the bulk of the institution's traffic, utilizing 15 separate communications systems.

The centers will duplicate each other in much of the equipment that will stud their 32-conduit consoles. Thus, in an emergency, one could do the assigned tasks of both. If the control center were "lost" during a riot, for example, the message center could still maintain contact with almost every inch of the prison. As an added security precaution, the corridor between the two centers will be sectioned by four automatically operated, heavy steel grille doors.

At each of the barred doors along the corridor leading from the prison entrance in the administration building to the visiting rooms and the heart of the insti-

Maximum surveillance is a built-in feature of the Marion penitentiary's pinwheel design, shown in the artist's drawing at right



CONTROL CENTER

Here, at hub of pinwheel layout, guards can see the full length of all four corridors and continuously keep an eye on inmates going from any wing to another.



REMOTE-CONTROL GRILLE DOORS

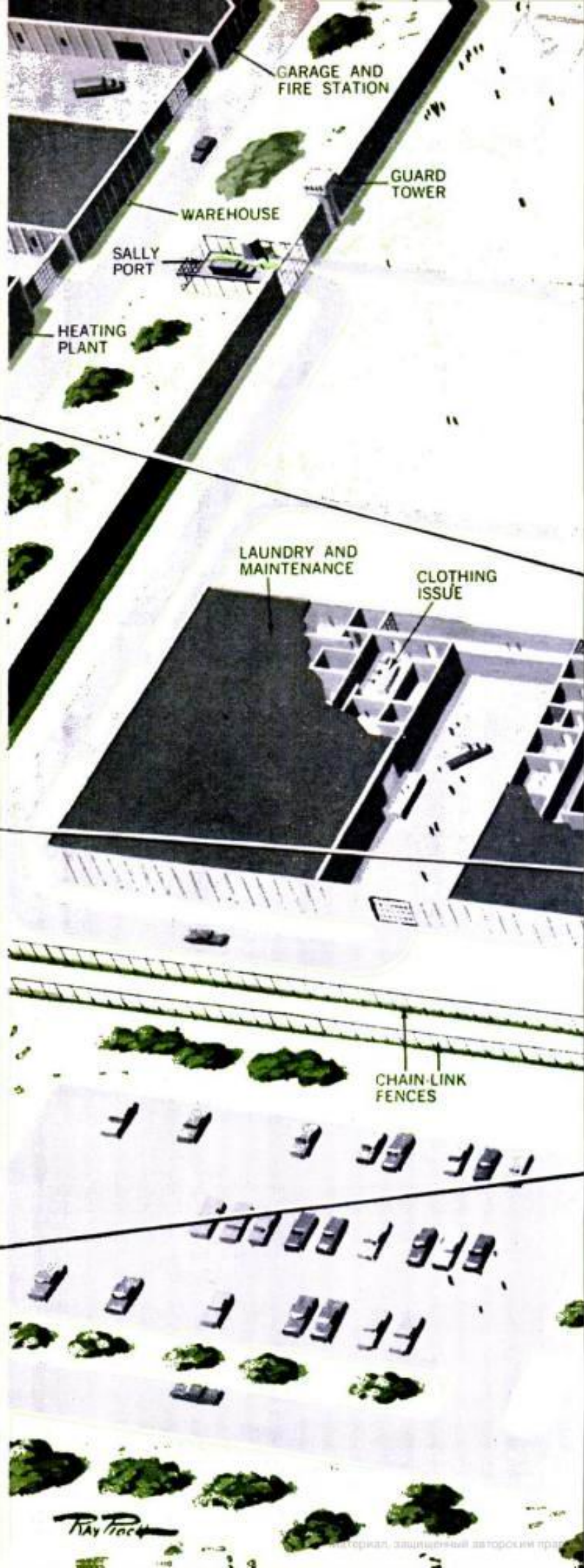
At these doors in corridors connecting control center with visitors' rooms, prisoner must identify himself by showing pass to TV camera, speaking into microphone.

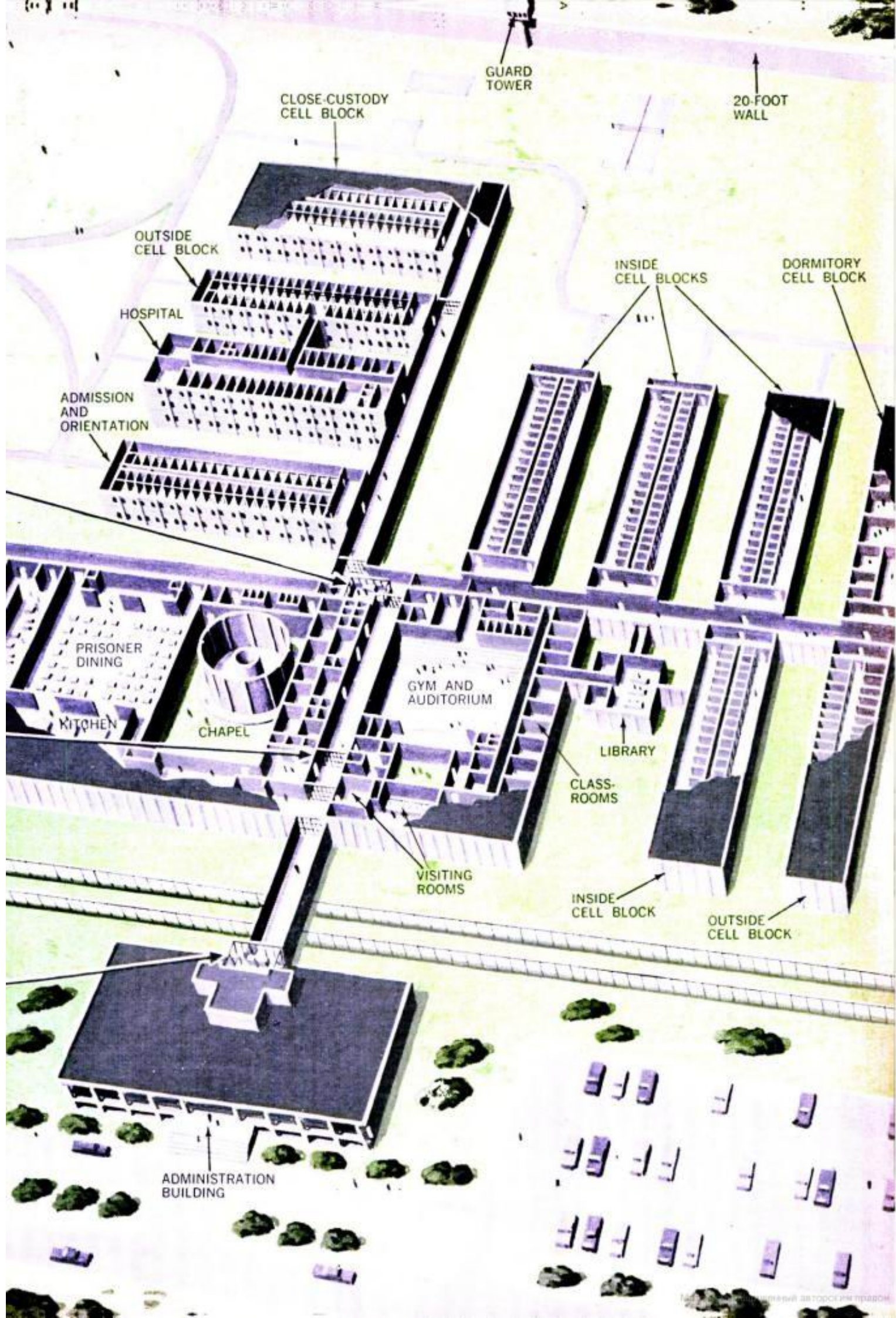


MESSAGE CENTER

On TV screen, guard checks prisoner's pass against index file. If errand is legitimate, guard presses button to open door electrically and let prisoner through.

CONTINUED





CLOSE-CUSTODY
CELL BLOCK

GUARD
TOWER

20-FOOT
WALL

OUTSIDE
CELL BLOCK

HOSPITAL

ADMISSION
AND
ORIENTATION

INSIDE
CELL BLOCKS

DORMITORY
CELL BLOCK

PRISONER
DINING

KITCHEN

CHAPEL

GYM AND
AUDITORIUM

LIBRARY

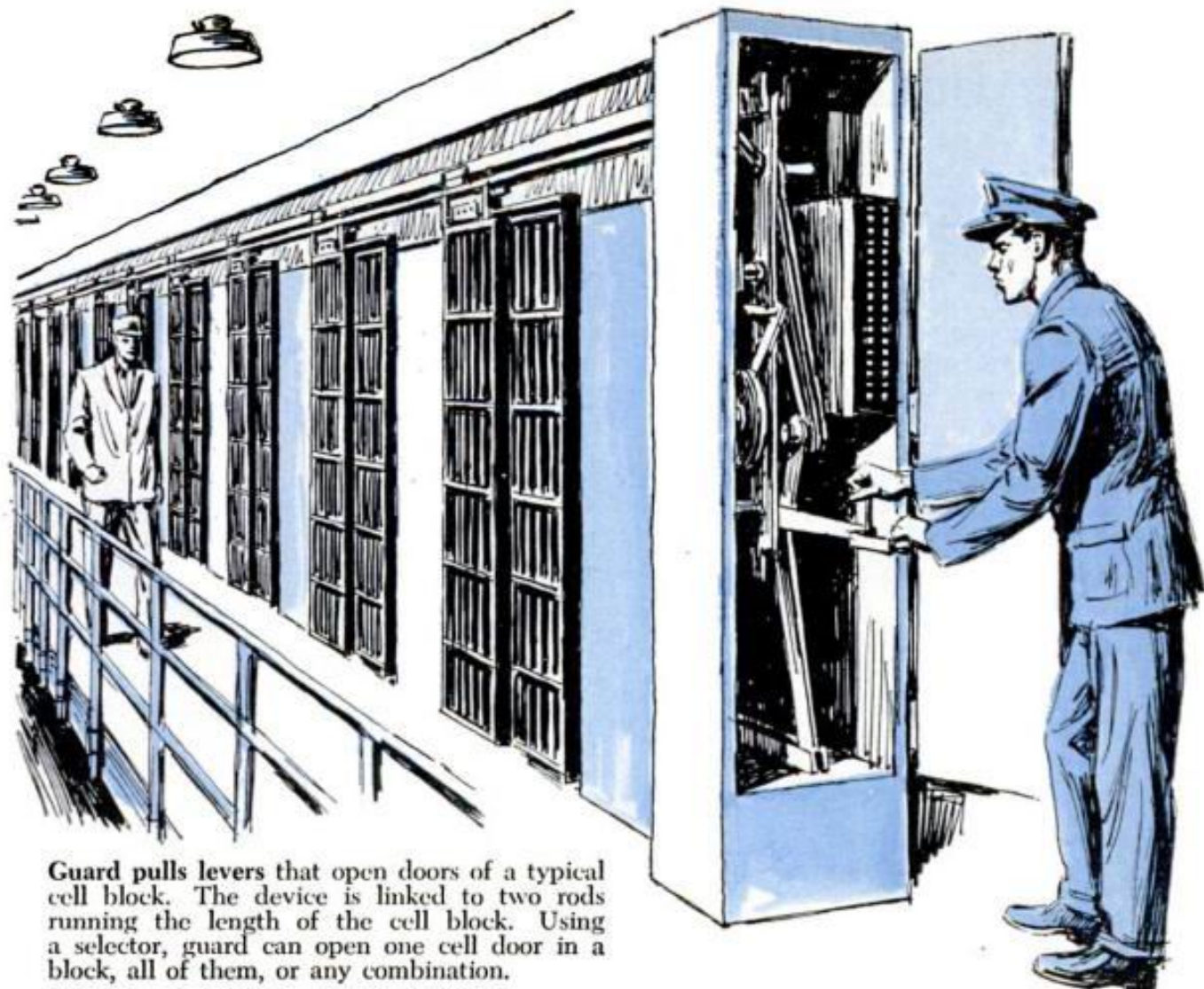
CLASS-
ROOMS

VISITING
ROOMS

INSIDE
CELL BLOCK

OUTSIDE
CELL BLOCK

ADMINISTRATION
BUILDING



Guard pulls levers that open doors of a typical cell block. The device is linked to two rods running the length of the cell block. Using a selector, guard can open one cell door in a block, all of them, or any combination.

tution, will be two closed-circuit TV cameras.

When a prisoner wishes to pass through a door, he'll speak to the control or message center through an intercom installed near the grille. The ceiling-mounted cameras will be activated, flashing his picture to the center's monitor and also revealing the hallway near the doors so that guards can be sure he's alone.

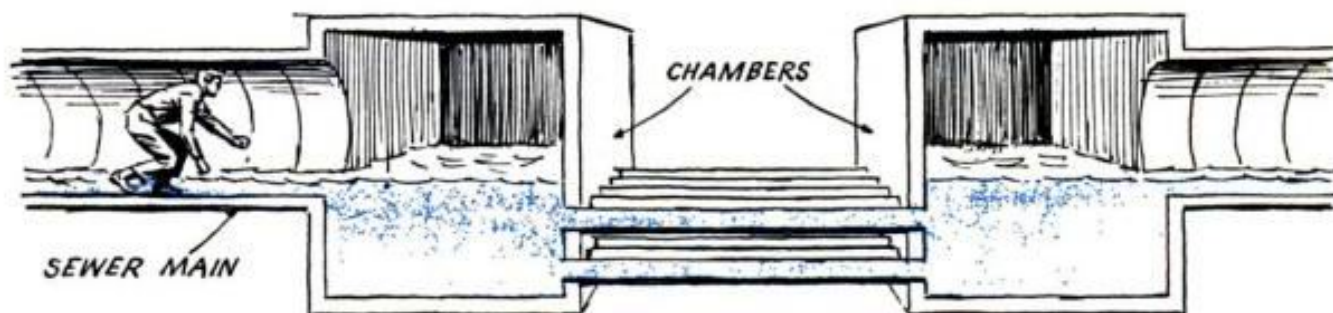
The convict will hold his pass up to the camera, and his name will be checked

on a rotary index file which will list his security status and the areas that are off limits to him. If he checks out okay, the door will be opened, electrically.

Eventually, the prison's closed-circuit TV will be expanded to peer over the 72-man cell blocks and the visiting rooms. Until then, on-the-spot guards will perform these chores.

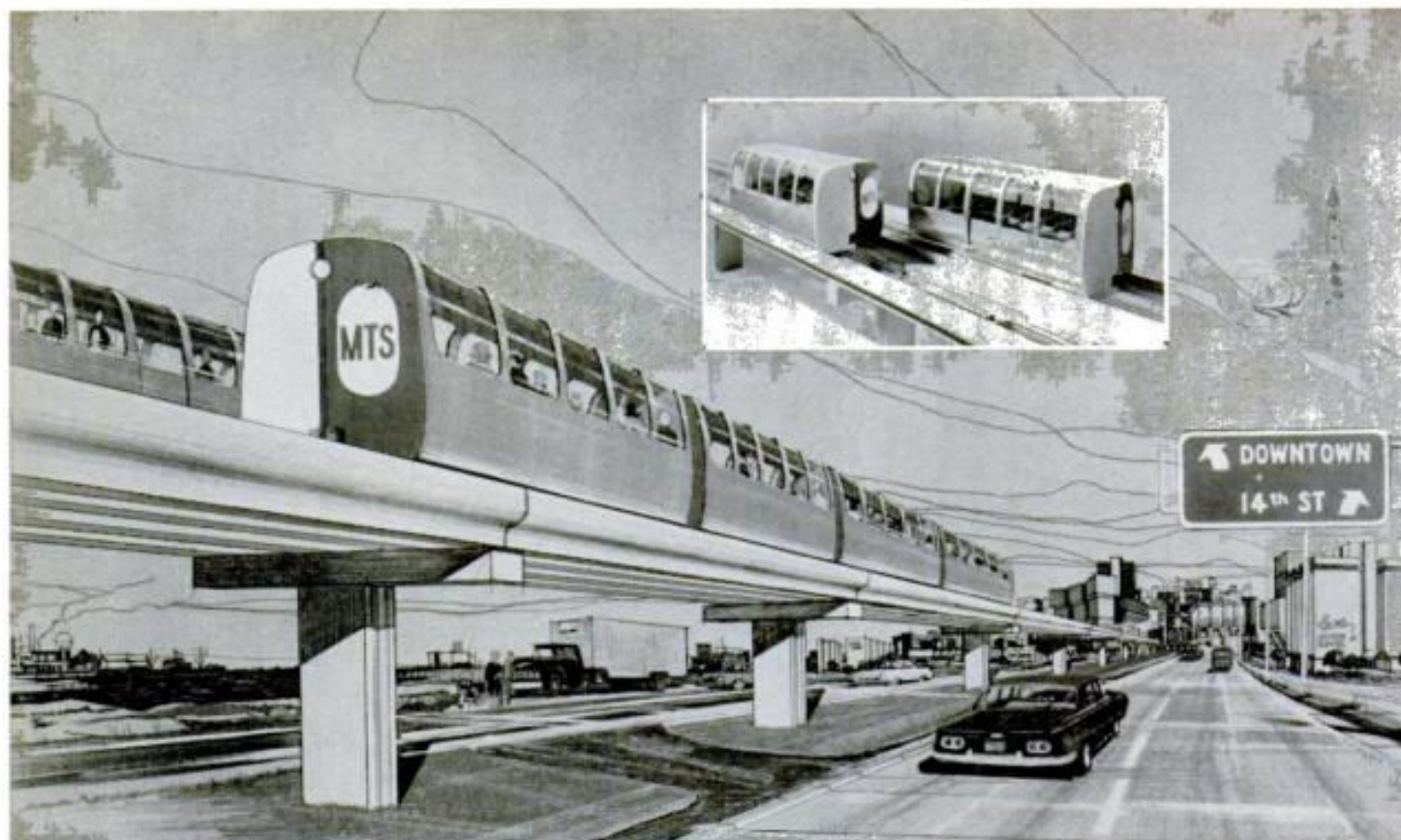
Listening in. Highly sensitive microphone-speaker units will listen for trouble

[Continued on page 167]



No escape through sewers: Four-foot main empties into a chamber. Sewage continues from

there through escape-blocking eight-inch pipes to another chamber, then back to a main.



Automated trains are shown here in drawing operating on a double track over median strip of electrified express highway. Structure would

be made of prestressed, precast concrete. In inset are models of bucket-seat aluminum cars, about a seventh the weight of typical rail cars.

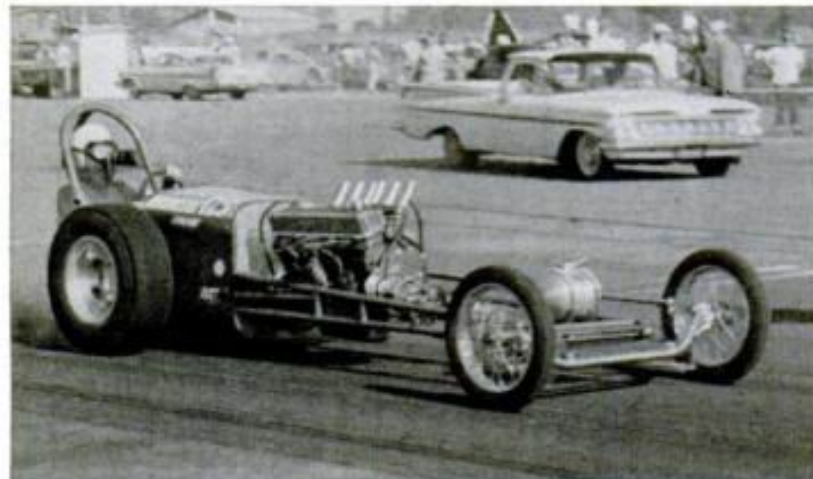
Driverless train for low-cost rapid transit

A rapid-transit system, automated and trimmed to size for cities with populations of 500,000 to 2,000,000, has been designed by Westinghouse at the instigation of the city of Pittsburgh. Rubber-tired aluminum electric cars would carry 20 passengers each in individual bucket seats. Power would be drawn from cables in the floor of an overhead expressway having high curbs on which four horizontal wheels would guide the vehicles. Dual tires on both axles would prevent delays on account of a flat.

Cars would run singly during off-peak hours, in trains of up to 10 cars made up by

punch cards in automatic switchyards during rush-hour operation. A central control computer, assisted by local controllers, would keep cars and trains at 50 m.p.h. on a two-minute headway, with automatic stops at stations spaced a mile apart. The system is designed to carry 5,000 to 14,000 passengers an hour in either direction.

With no motormen or conductors, labor costs would be reduced; with lightweight rolling stock, equipment would be comparatively inexpensive. Other possible users, says Westinghouse, are Atlanta, Baltimore, and San Francisco.



Six in a row for go

Successful six-cylinder dragsters are almost unheard of. But that didn't stop this Dragmaster, powered by a 225-inch Dodge Dart slant-six, from dusting off all V-8 competition and setting a new D/Dragster record.

Jim Nelson and Dode Martin of Carlsbad, Calif., added fuel injection, high-compression pistons, and racing camshaft. Best standing-start quarter-mile time: 126.22 m.p.h. in 10.64 seconds.



X-15's typical flight path to subspace and back

After the drop of 500-1,500 feet from its B-52 launch plane, X-15's rocket engine starts, if pilot is lucky. The 600,000-hp. engine is fed 4.2 tons of fuel (liquefied ammonia gas) and 5.2 tons of LOX (liquid oxygen) from outer wraparound tanks by pressure from helium in central tank. Pilot cuts engine, after less than two-minute powered flight, at 125,000 to 140,000 feet and continues, weightless, in ballistic trajectory over

the hump at border of space. Looking across 420-mile flight range, view here is easterly toward Las Vegas, with Sierra Nevada Mountains in lower right foreground. As X-15 falls toward earth and re-enters atmosphere, ship's undersurfaces must be presented at correct angle for frictional braking. Farther down, pilot regains aerodynamic control and lands at Edwards Air Force Base in California.

celeration G-forces shove the pilot against his harness with fierce energy. He might black out or come apart inside if it weren't for the body-gripping, blood-damming air bladders that automatically inflate his pressure suit.

Terrific come-down. Landing the 50-foot plane-missile is like driving a car at racing speed on the bare rims of its rear wheels. The X-15's landing field is a hard-baked dry lake. It sets down on two three-foot steel skids and a pair of small nose wheels at 180-225 m.p.h., and

slides for a mile or more before it stops.

It was during such a landing that one of the three X-15s, ship No. 2, was wrecked last November 9. After dropping from the mother plane, pilot Jack McKay discovered that his engine was unable to reach full power. He shut down the engine and made an emergency landing on Mud Lake, 195 miles from home base. The nose-wheel support collapsed at the end of his landing slide, and the ship flipped over. McKay had anticipated trouble and had blown

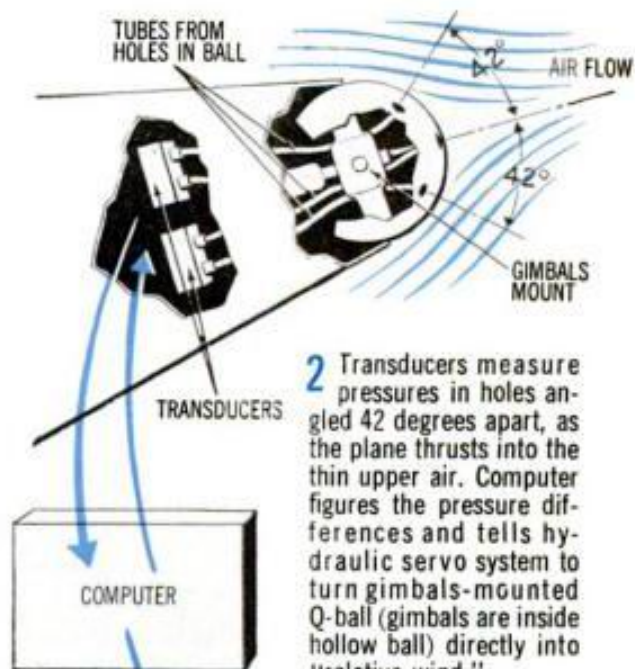


Inside Q-ball: Hollow nickel-chrome ball, cooled by liquid nitrogen, can take 4,000 degrees F. and pressures up to 2,500 lb. per sq. ft. It's made by Northrop's Nortronics division.



How X-15 is aimed for re-entry

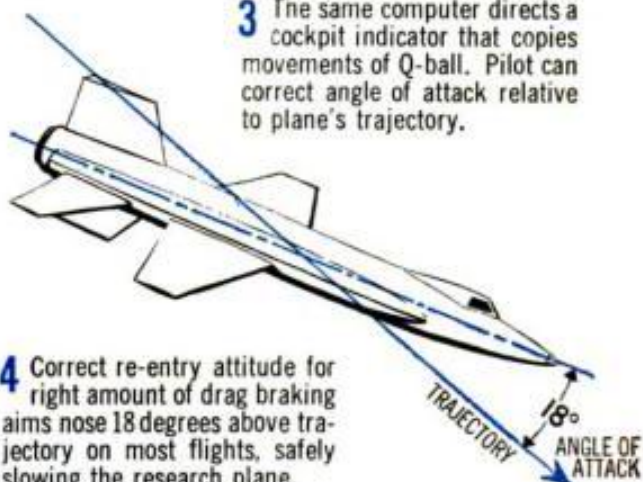
1 Q-ball, at tip of X-15's nose, and jets of steam (generated by hydrogen peroxide) from miniature rocket motors, also shown, are both needed for ship's return to earth. Q-ball senses X-15's critical "angle of attack."



2 Transducers measure pressures in holes angled 42 degrees apart, as the plane thrusts into the thin upper air. Computer figures the pressure differences and tells hydraulic servo system to turn gimbals-mounted Q-ball (gimbals are inside hollow ball) directly into "relative wind."



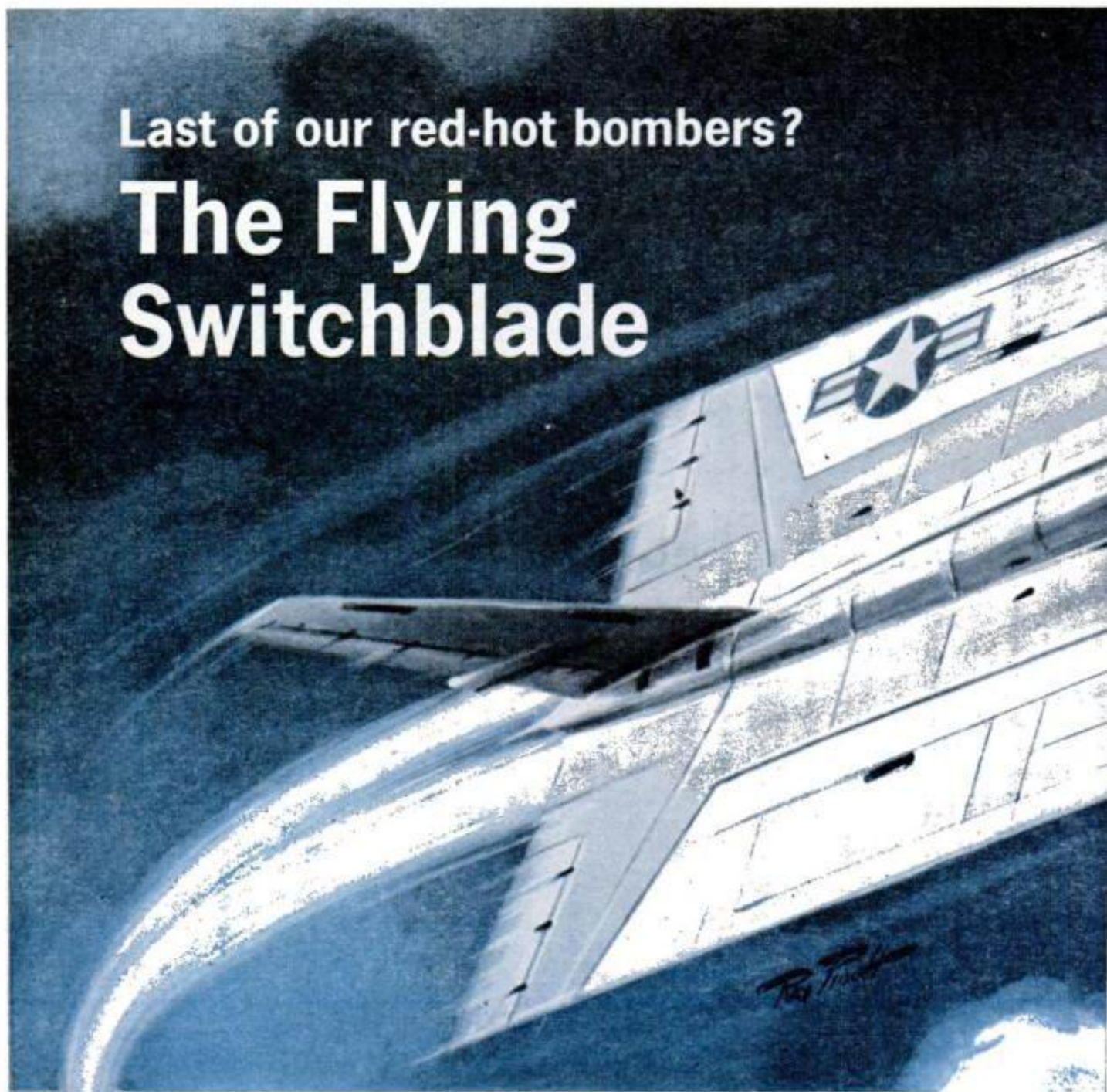
3 The same computer directs a cockpit indicator that copies movements of Q-ball. Pilot can correct angle of attack relative to plane's trajectory.



4 Correct re-entry attitude for right amount of drag braking aims nose 18 degrees above trajectory on most flights, safely slowing the research plane.

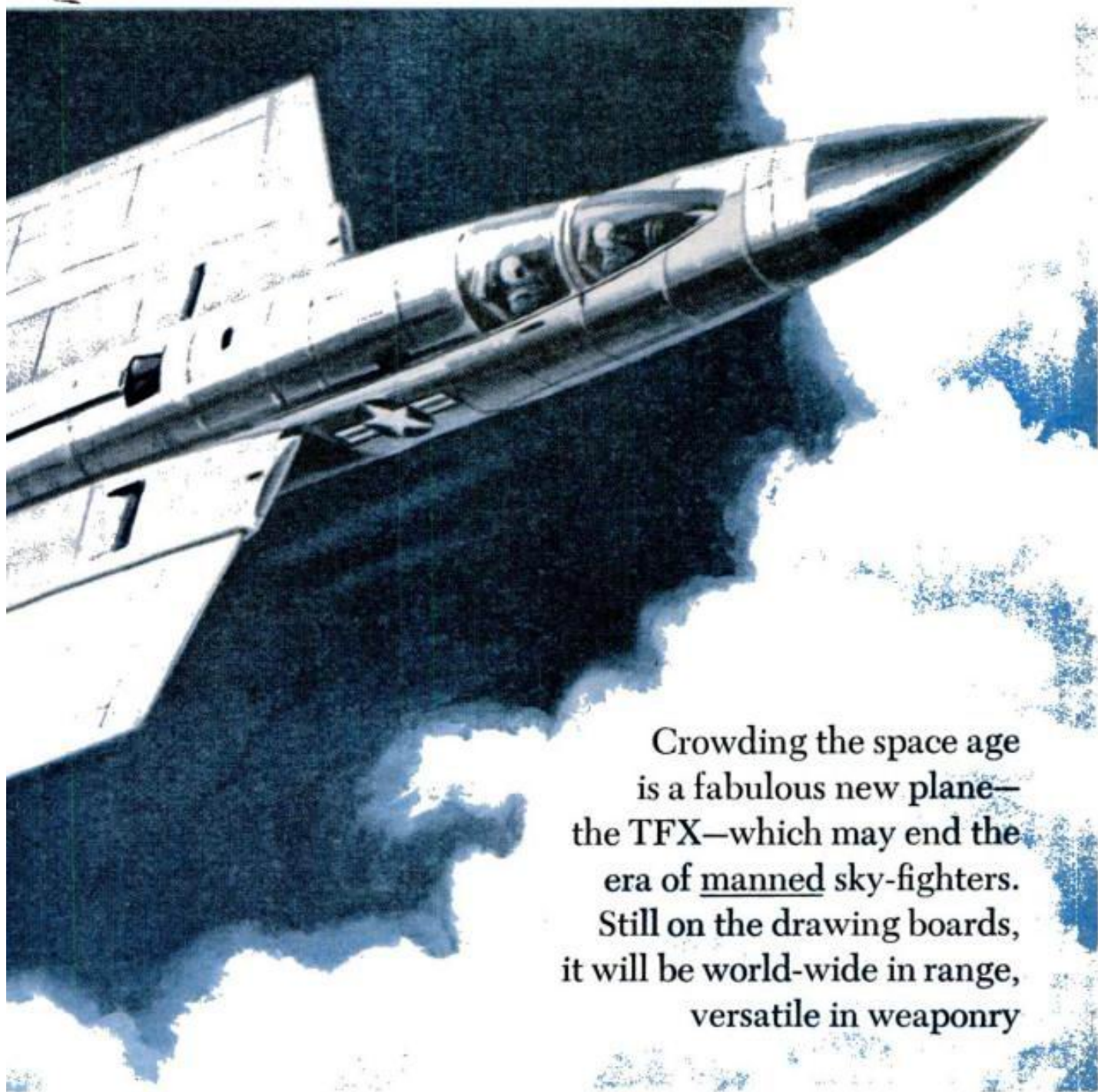
Last of our red-hot bombers?

The Flying Switchblade



Variable-sweep wing, which can be moved in flight, will make the TFX a fighter-bomber pilot's dream come true. With the wing fully spread out, he can take off from and land on small fields at low speed; sweeping the wing partly back, he can cruise great distances with fuel economy; with the wing hugging the fuselage, his plane becomes a rectangular aerodynamic platform for a supersonic dash over the target.



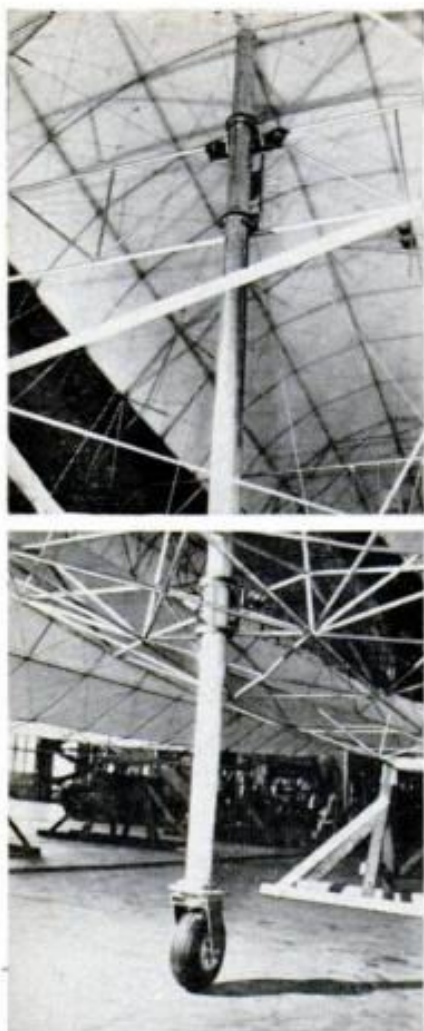


Crowding the space age is a fabulous new plane—the TFX—which may end the era of manned sky-fighters. Still on the drawing boards, it will be world-wide in range, versatile in weaponry

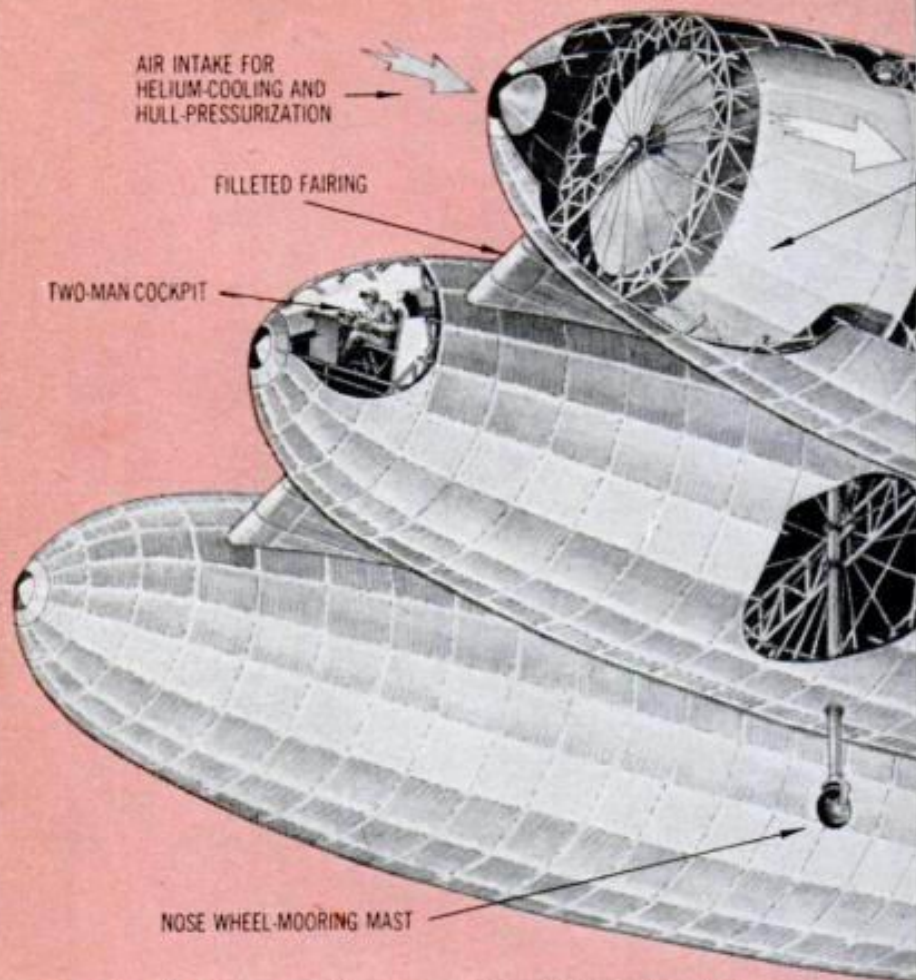
By Frank Harvey

A LONG-TIME dream of aviation designers is now very close: an airplane with wings that can open or shut in flight like the blade of a knife—allowing a pilot to “shift gears” in the sky. They call it TFX—Tactical Fighter, Experimental—and every big aviation company in the U.S. and Europe has been hoping to pluck this biggest, juiciest plum left on the tree: The TFX may quite possibly be the last of the manned fighters. The winner not only gets multibillion-

dollar military orders (the TFX is intended to be used by the Air Force, Navy, and Army in various configurations) but a glittering bonus as well. The know-how gathered in government-subsidized military production can be applied to the design of civilian transports. For the variable-sweep wing is not a risky paper concept any longer. The bugs have been worked out in wind tunnels. And here is an authentic case where a designer can have his cake and eat it, too. A switch-blade airplane can slow down to land on short fields, can lift out of those short



Nose landing wheel is also a built-in mooring mast. Swivel plate just above wheel is for tying the airship down on the ground. The telescoping strut extends up into the center hull where the stress is distributed among frame members.



Tom Swift Flies Again! Aereon III triple airship (shown above in partial cutaway) is, according to its designer, John R. Fitzpatrick, an experimental flying laboratory to test new principles of airship construction and operation. Future Aereons might be 1,000 feet long, carry 100 tons of cargo cheaply, be nuclear powered.

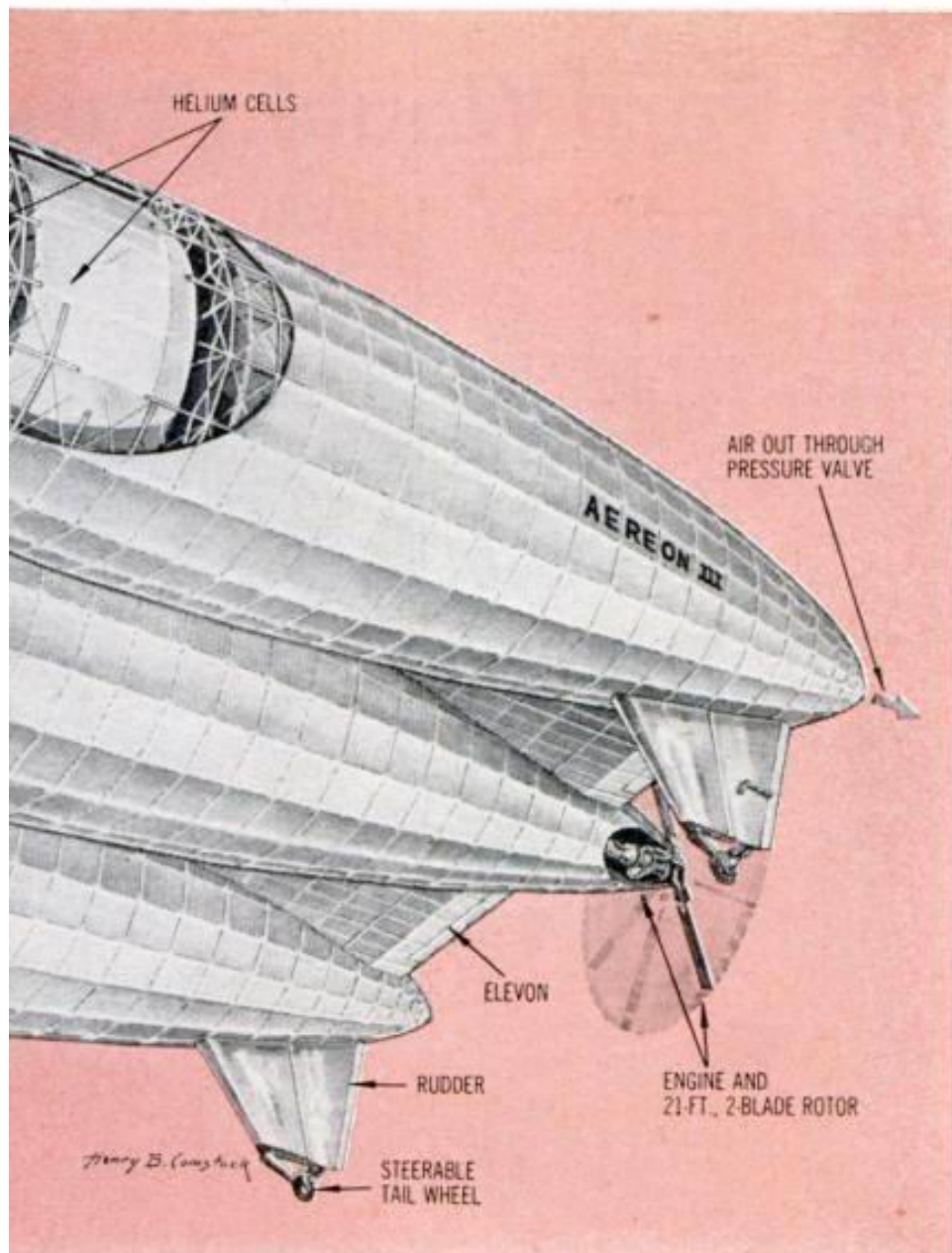
I, back in 1863," said Mr. Drew. Then he explained that his own interest in airships dated back several years to one afternoon when his youngest son, Malcolm, came home from his sixth-grade classes loaded with questions about lighter-than-air ships. The father, not knowing the answers, decided to find out. During his research he came across an article in the January, 1932, issue of *POPULAR SCIENCE*, "He Flew Before the Wrights Were Born." It was a detailed account of Dr. Andrews' amazing aerial-navigation feats with his trigible during the Civil War.

The three-hulled Aereon I fascinated Drew, and led to the forming of a company to build Aereon III. (Dr. Andrews

built a single-hulled Aereon II, but it was abandoned for lack of interest and funds.)

"Gravity power." Although the newborn Aereon has a small rear-mounted turboprop engine, it can achieve forward speed by "gravity power" alone—the only means of propulsion Dr. Andrews had, except when he was flying with the wind.

How does this "built-in tailwind" work? Very simply, explained the designer of the Aereon III and the company's chief engineer, John R. Fitzpatrick, a 40-year-old retired Navy lieutenant commander and aeronautical engineer. He describes the craft as "a large symmetric airfoil exerting enormous lifting force in



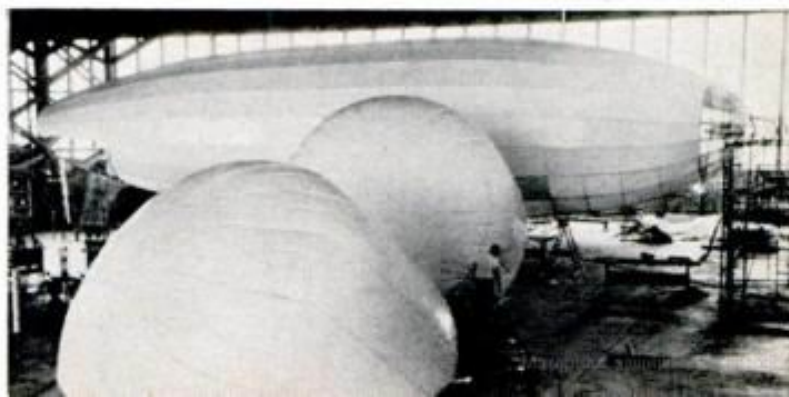
Important innovation is the use of a new superstrength plastic film, Tedlar, sections of which are shown here being pressure-taped together. The nonflammable, white-pigmented material is used both for the outer hull skin and the helium cells.

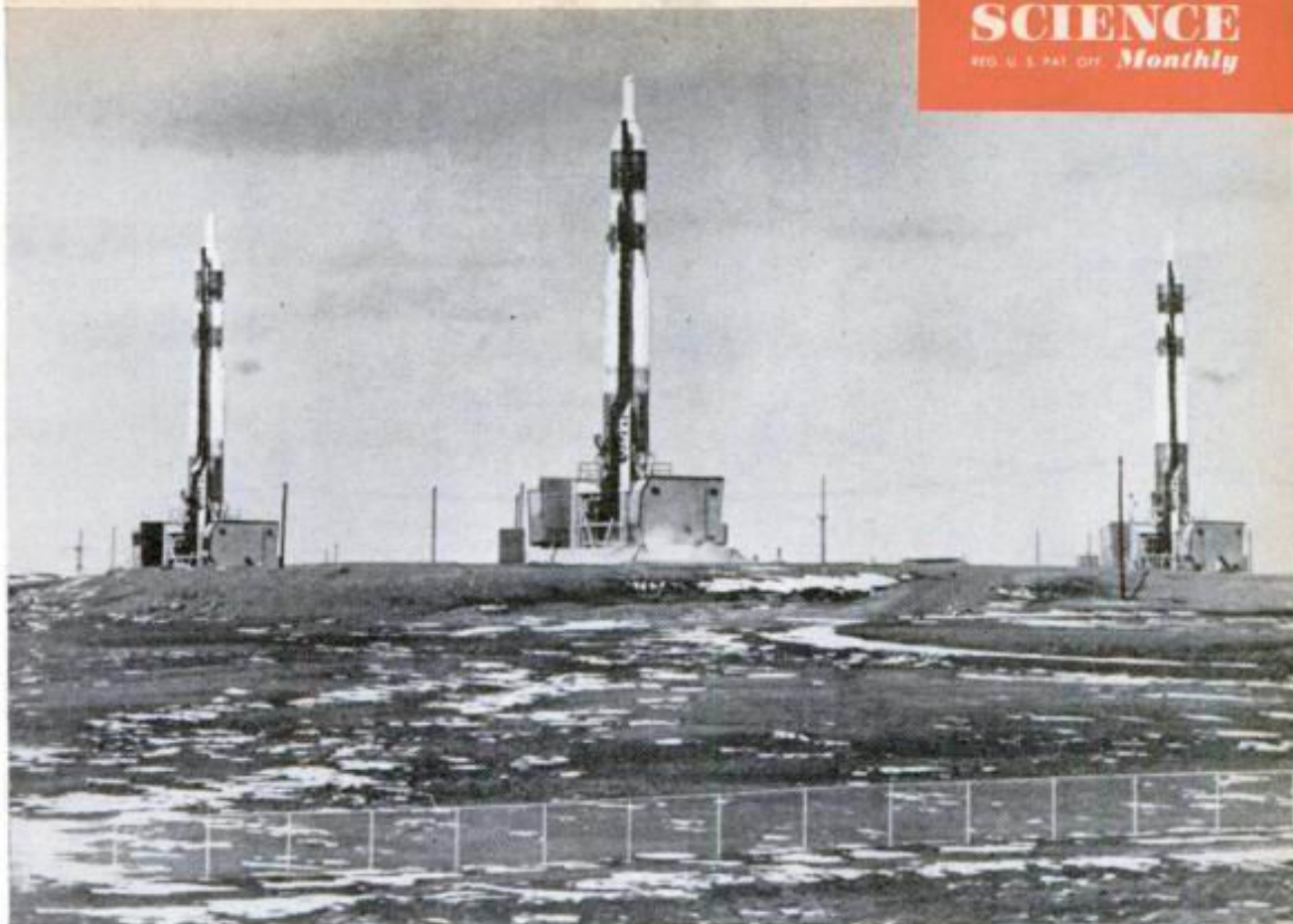
flight." As the gas cells within the hulls are filled with helium, making the ship lighter than air, it rises like a balloon. Then, by using control surfaces to change its angle of attack, tilting it about five degrees nose up, it goes not only up but forward, gaining speed for free. On reaching altitude, say 10,000 feet, the airship is made heavier, and the nose tilted downward for a forward descent.

By repeating this up-and-down maneuver, Dr. Andrews, according to newspaper reports of 1863, flew at more than 120 miles an hour without benefit of wind or engine. His range was limited, however, because he could carry only so much ballast to dump for lightening, and just so much hydrogen gas could be valved to make the Aereon I heavier.

[Continued on page 202]

Partially inflated helium cells are tested for tightness of taped seams. In the background is one of the 83-foot-long Aereon III hulls with its outer skin nearly completed. A one-inch air space separates that outer skin from an inner nylon skin.





Three Titans, first of invulnerably "hardened" ICBMs, stand ready to go from Colorado ridge.

Underground with the TERRIBLE TITAN

Those aren't prairie-dog holes Uncle Sam has been digging on the Great Plains. Here's a PS editor's report on what goes on in missile complexes from Colorado to Montana

By Martin Mann

"THIS is the year of the big pay-off in missiles," says Air Force Major General Thomas Gerrity, who makes them.

At the beginning of 1962, the U.S. had 54 Atlases, eight-story-tall rockets that can circle the globe to wipe out cities, but are themselves vulnerable to attack. In April, the first Titans—bigger and deadlier—went into underground silos, impregnable to anything but a direct hit. Later this year the smaller and cheaper

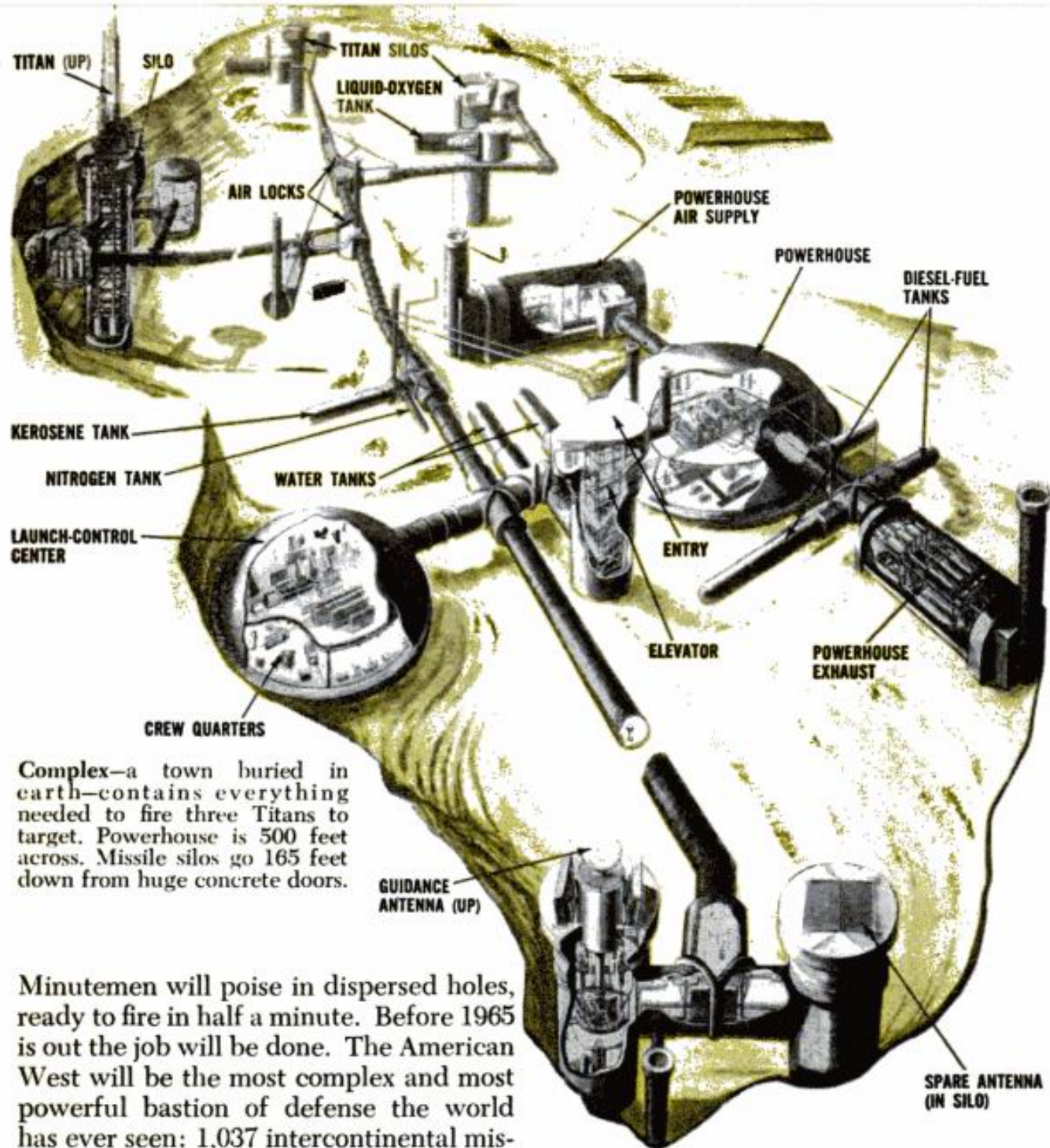


★ SAC HEADQUARTERS ● TITAN ○ ATLAS × MINUTEMAN

Formidable force of H-bomb-armed long-range missiles is concentrated almost entirely in West, far away from our biggest population centers.

CONTINUED

35



Complex—a town buried in earth—contains everything needed to fire three Titans to target. Powerhouse is 500 feet across. Missile silos go 165 feet down from huge concrete doors.

Minutemen will poise in dispersed holes, ready to fire in half a minute. Before 1965 is out the job will be done. The American West will be the most complex and most powerful bastion of defense the world has ever seen: 1,037 intercontinental missiles that no sneak attack can disable, that can almost instantly strike back to destroy an aggressor.

That's what they say. I have seen some of it, and the claim appears reasonable.

DRIVING along Colorado Route 30 about 25 miles southeast of Denver you see the Rockies jutting up on your right, a long, low ridge carpeted in alfalfa off to the left. The ridge sprouts what seem to be three tall pine trees. They aren't. They are Titans, lifted from their silos to firing position. Each stands 10 stories high and can rocket across continents to blast a bull's-eye with the force of 12 million tons of TNT.

When the Titans are down—as they usually are—nothing shows from the highway. Only a dead-pan sign, "Site A-1," hints that buried deep beneath the ridge are monstrous weapons, a fantastic maze of tunnels, elaborate electronic controls, huge tanks of kerosene and liquid oxygen, generators big enough for a town of 10,000, and 11 coolly alert men.

The sole building on the ridge is a green-painted plywood shack. It encloses an elevator (for freight or visiting firemen like me) and a stairway (for the crew). Six stories down and you are in the core of the weird space-age fortress.



Construction of U.S. ICBM bases (above is one Titan complex) dwarfs that of Pyramids.

Total of 37,550,000 cubic yards of dirt will be dug, 2,647,000 cubic yards of concrete poured.

It looks vaguely like a ship. The tunnels are corrugated steel cylinders half choked with pipes and cables. Everything is bright yellow or green; you can still smell fresh paint. You notice the fluorescent lamps. They hang on springs. And the iron pipes suddenly change back and forth to rubber hose every few yards. This is your first introduction to

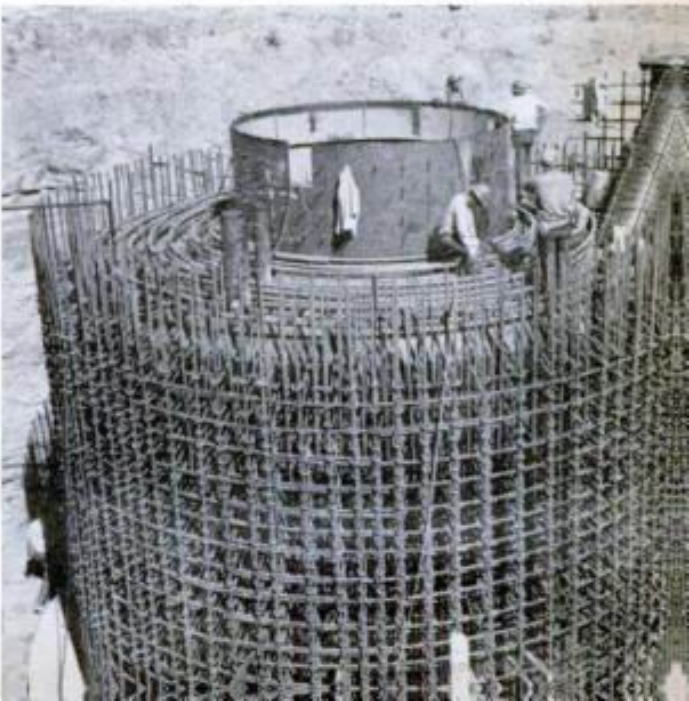
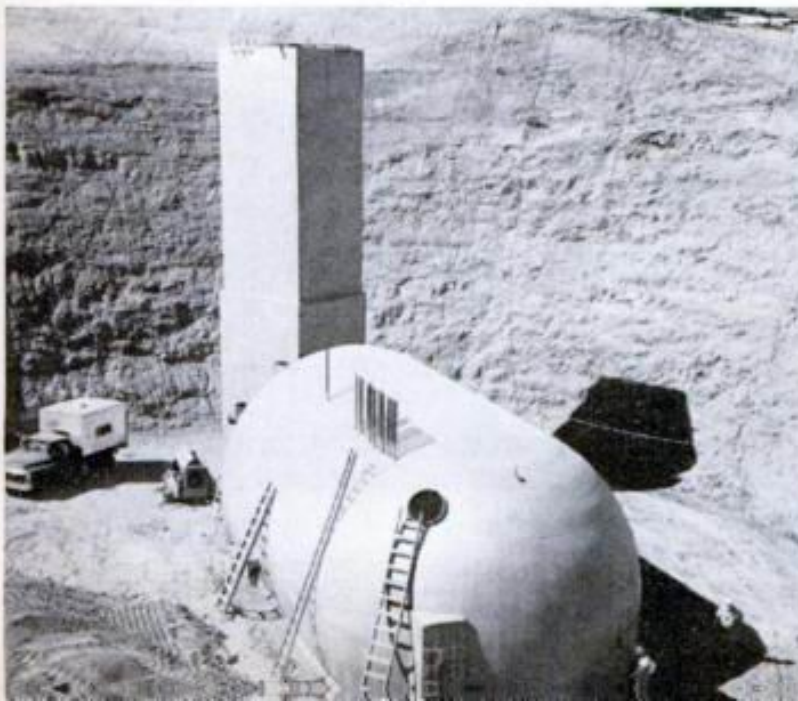
blast-resistant construction. A near miss will shake things up, but not wreck them.

The Titan complex is laid out like a small town. Main Street is one long tunnel—a quarter of a mile—running from the missile silos at one end to the guidance antennas at the other end. (The antennas, which transmit steering signals to the rocketing missiles, stay under-

CONTINUED

Minuteman sites are small and simple—but there will be a lot of them. Tanklike structure (shown before dirt was filled in) is the two-man control center; "chimney" is elevator shaft.

Why missile silos can't be knocked out: Thick walls are heavily reinforced with steel. For Minuteman silo (below), concrete is mixed in forms by squirting grout through dry gravel.





Tunnels totaling half a mile in length interconnect sections of underground Titan fortress. This photo shows some of the elaborate precautions that enable complex to shrug off H-bomb attack: Notice flexible sections in piping at lower right and looping down from upper right and left. Fluorescent lights hang from springs. Covered trays at left side of tunnel carry cables for power and control.



Titan is steered during first 10 or 15 minutes of flight by radar signals controlled from this console. Rectangular screen (center) shows TV picture of missile as seen from ground.

Visitors can't miss the point of billboard at SAC headquarters. This is a spit-and-polish outfit—pipe the guard's get-up: beret, scarf, fourragère, fancy belt, horn-handled .38.



ground until button-pushing time; then one rises to the surface—the other is a spare.) Short side tunnels branch off Main Street to the Launch Control Center and to the powerhouse.

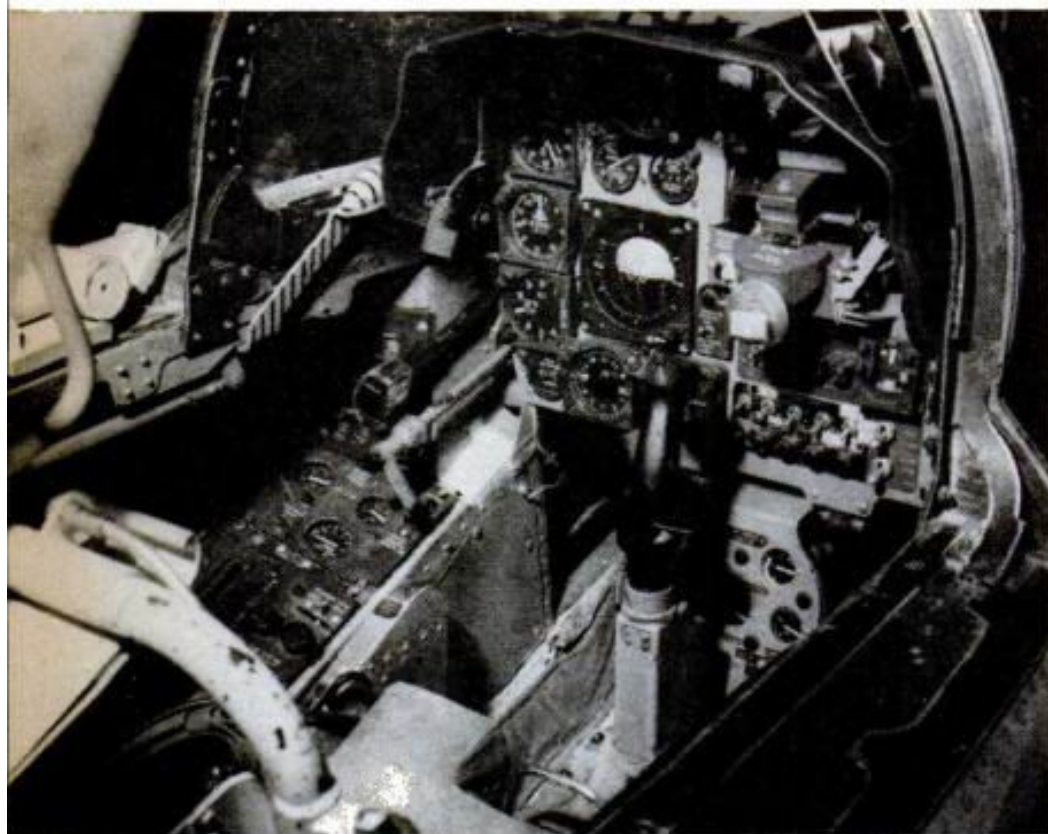
The powerhouse is huge: three open levels under a domed ceiling, four roaring diesel generators. A movie theater would be lost in this concrete cavern.

You begin to see where 60-odd million tax dollars went: enough concrete for the basements of 1,400 houses, enough steel for 9,700 cars, enough wiring for 1,600 houses, enough electronic parts for 66,000 radios, enough air conditioning for 250 houses, enough diesel fuel to take a freight train from Denver to New York and back—23 times.

THE missile silos are oddly disappointing. The approach is dramatic enough: an air lock with blastproof armor-plate doors that are electrically interconnected so you can't open one unless the other is closed. The inner door leads to a narrow steel-mesh landing at about the 11th-story level of a 165-foot-deep hole. Only you can't see much. The silo is completely lined with heavy steel cribbing. The crib, which supports the missile and its elevator, stands free of the silo wall on springs (for blast protection).

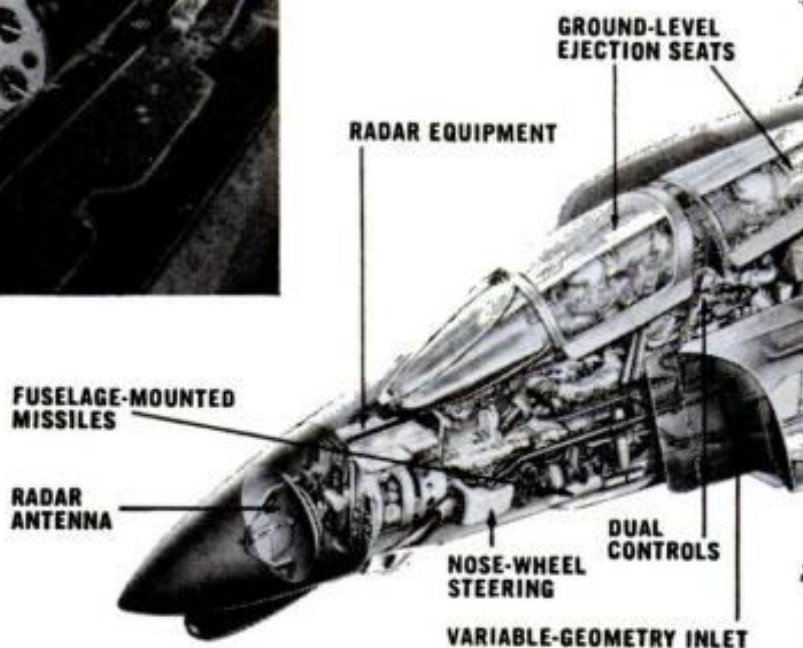
But when you come to the Launch Control Center, there's no disappoint-

She can fight like the devil and run like hell, but to her crew she's

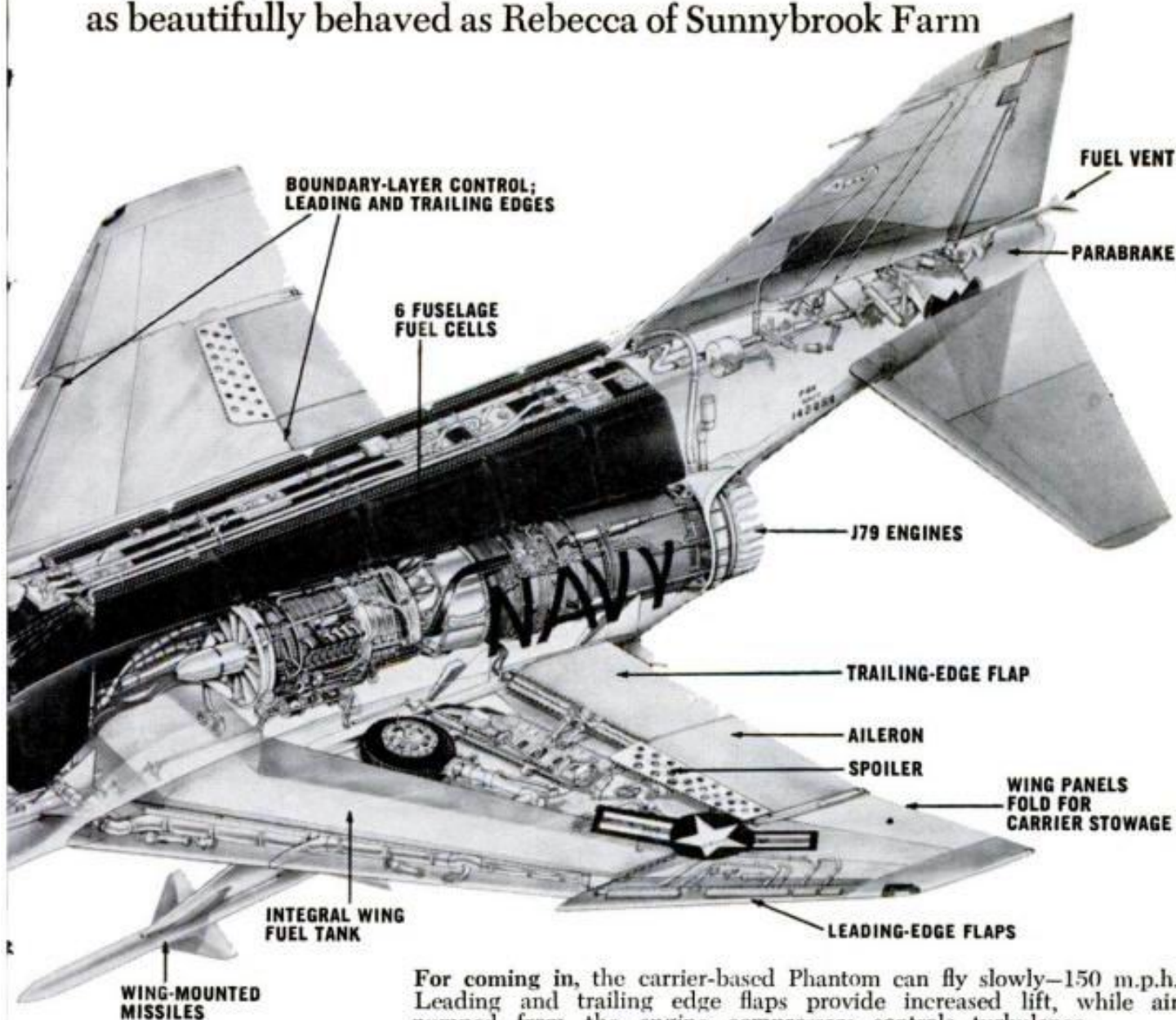


Forward cockpit of F4H has just squeeze-in room for pilot. (Radar man rides aft.) Left of center above altimeter is Mach indicator. Emergency canopy-jettison control is left of seat.

Lethal loads: Sparrow III and Sidewinder missiles perch under the wings and fuselage. She can also tote A-bombs.



as beautifully behaved as Rebecca of Sunnybrook Farm



For coming in, the carrier-based Phantom can fly slowly—150 m.p.h. Leading and trailing edge flaps provide increased lift, while air pumped from the engine compressors controls turbulence.

she's so gooney looking I wondered how she could ever get off the ground.

Her beaklike nose droops out of a barrel belly. Her wings bend up at the tips. Her fin is about as graceful as a homemade weathervane. A little kid seeing the plane for the first time screamed excitedly, "Look, Mom, they got the tail on upside down!"

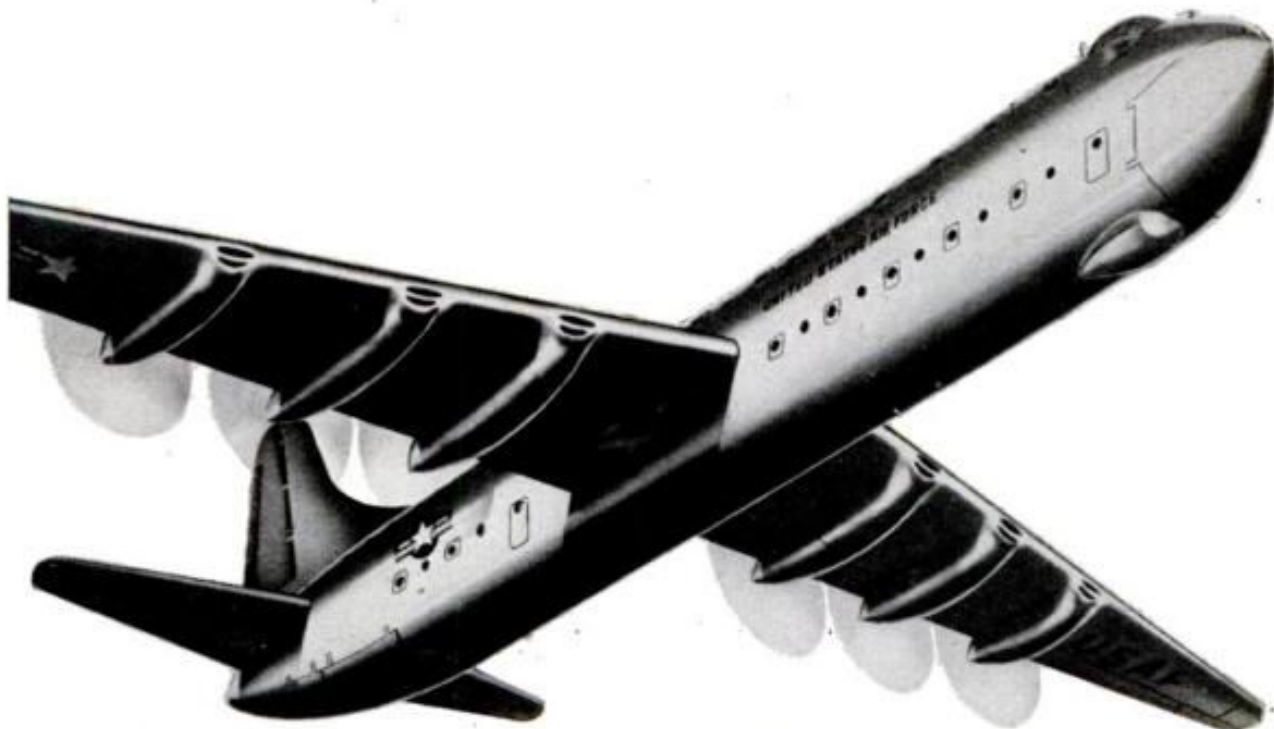
Double threat. But McDonnell Aircraft, makers of the Phantom II, couldn't care less. The plane happens to be the hottest jet in the world. So impressed is the Tactical Air Command that they're thinking of buying 500 Phantoms—at \$2 million apiece. The reason? The plane's versatility. She's a long-range bomber. She's a fighter—the toughest, fastest in-

terceptor we have. And count these among her laurels:

She holds the low-level speed record: 932 m.p.h. on the deck over the Mojave Desert in a run aptly called "Sageburner." And the altitude speed record: 1,606 m.p.h. (Mach 2.55). She can also sustain herself in level flight above 66,000 feet, then zoom to over 98,000.

She is impressively long-ranged, can refuel in mid-air, and take off and land in about half the distance of jets with half the speed, a fact that suits TAC—as well as the Navy—to a T.

The clincher, as far as the boys who handle her are concerned, is that the bird is as beautifully behaved as Rebecca of Sunnybrook Farm. She forgives mis-



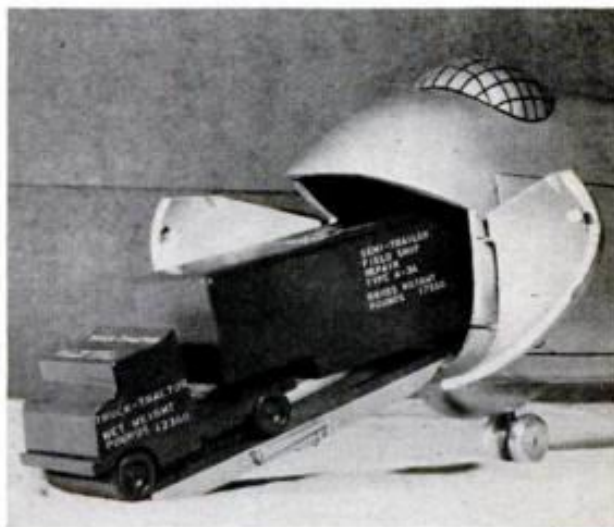
Proposed cargo version of B-36 bomber could carry a medium tank and 30 equipped troops.

U.S. to Europe with 50 Tons

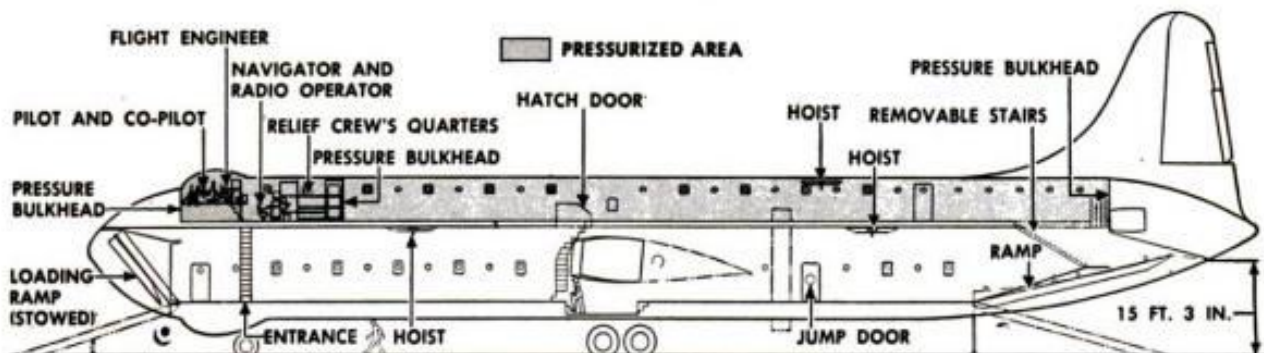
THIS cargo version of the Consolidated-Vultee B-36 six-engine bomber, submitted as a design proposal to the U. S. Air Force, would carry a record load of 400 fully equipped troops or 50 tons of materiel across the Atlantic at over 300 m.p.h.

The double-decked C-99, as the plane has been labeled, is an outgrowth of the XC-99 experimental transport. It could take off from U. S. bases with a full load and fly nonstop to any point in England or western Europe. One version of it could tote 343 litter patients and 33 attendants. Its 21,715 cubic feet of usable space is an increase of more than half again as much as the XC-99 contains. Forty-four of the airplanes could transport an entire air-borne division.

The entire upper deck, including crew's compartment, would be pressurized. **END**

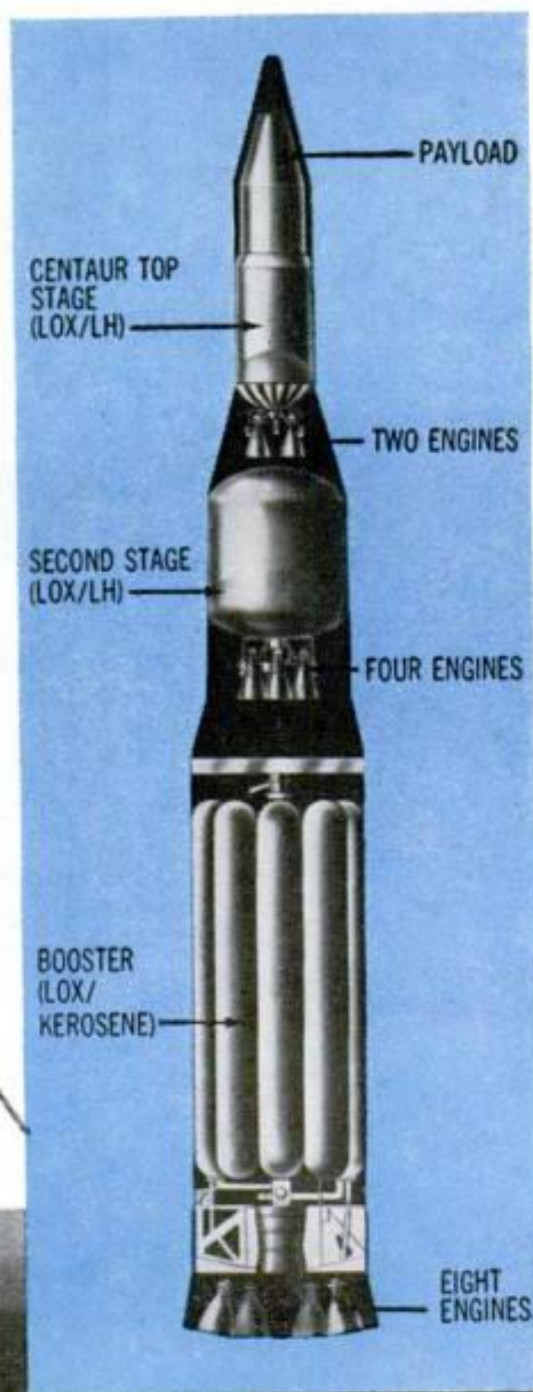
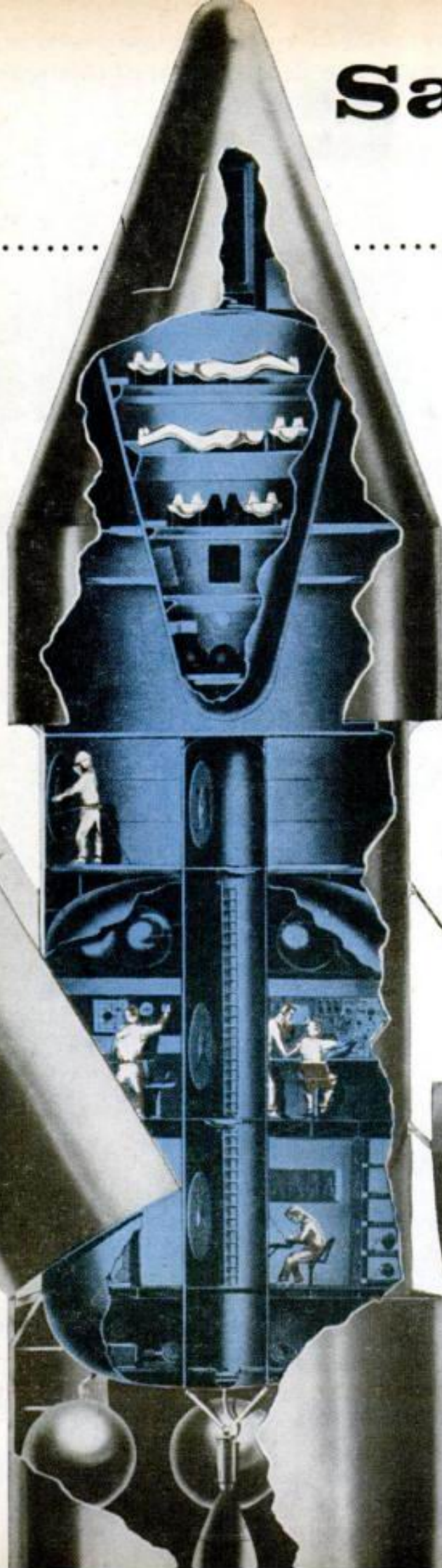


Clamshell doors at front and rear of fuselage would provide entrances measuring almost 12 by 13 feet, sufficient for trucks and trailers. Upper deck alone could accommodate 183 troops.



Profile drawing of proposed transport shows pressurized area, hoists for lifting, stowing cargo.

Saturn: Our Biggest



MANNED SPACE LAB, Wernher von Braun thinks, will be flung into orbit by a later, even bigger version of the 185-foot, 580-ton Saturn rocket (above). The crew (left) would ride in the nose cone during launch and return journey. Those hinged shields on the lab's sides could collect solar rays for power or act as brakes.

When Will We Start Burning Water?

**The hope: unlimited power.
The fuel: water. The date:
not tomorrow . . . but soon**

By Harland Manchester

ABOUT 1,000 scientists and engineers in eight countries are now designing, building, and testing a variety of strange new machines in a race to solve one of the most inspiring and baffling riddles man has ever put his mind to—how to harness the fusion might of the hydrogen bomb and convert the killer into a docile engine that will produce power unlimited from water.

The basic facts behind this ambitious plan seem quite simple. All water contains a minute bit of "heavy water," compounded of an isotope of hydrogen that has an extra particle in its nucleus. These special atoms, as scarce as four-leaf clovers, constitute about 1/6,000 of water everywhere. Yet there are enough of them in a glass of ordinary water—if combined under certain conditions in a reactor—to supply energy sufficient to drive a car 400 miles or to provide electricity for an average American house for a month. If all the heavy water in the world's oceans, lakes, and streams were converted into power, it would equal the energy of about 17,500 billion billion gallons of gasoline, or supply all the world's needs for 10 billion years or so. This super-fuel, which looks like ordinary water and is only a little heavier, should be dirt cheap if extracted in bulk.

Deuterium plant concentrates the one part heavy water present in 6,000 parts river water by complex chemical, electrical, and distillation processes. Electrolysis separates heavy water (D_2O) into deuterium and oxygen

Deuterium gas to be added to fuel mixture

Water-treatment plant

DAVID JAMES

A fusion reactor could not, of course, operate on heavy water in its watery form, any more than car engines run on petroleum. From heavy water it is easy to extract the actual fuel, the "heavy hydrogen" that is called deuterium. The deuterium would be "burned" in gaseous form in a fusion reactor to make electricity. In existing atomic plants operated by fission, the giant nuclei of uranium-235 atoms are smashed into small fragments, and some leftover matter is converted into energy. In a fusion plant two tiny deuterium atoms would be combined to make one atom of helium with a far greater conversion of unused mass into energy. This is no guesswork: The sun and millions of other stars have been doing it since time began, and life on earth is made possible by the great solar thermonuclear fusion plant.

Scaled down to earthly size, such a plant could heat steam to drive turbines, as do today's atomic plants; but scientists believe that fusion offers a much better chance of converting energy directly into electricity, eliminating the cumbersome steam cycle.

Reactor fuses deuterium and tritium, releasing heat that generates steam

Steam from reactor spins turbines that drive dynamos in ordinary way

Power distribution

Offices

Tritium gas to be added to fuel mixture

Lithium mud to tritium plant

Tritium plant processes lithium mud circulating around reactor to recover tritium gas, which is manufactured from lithium by reaction

Water to cool reactor magnet coils

How Fusion Makes Electricity

Electricity for the entire city of Detroit—about 2,000,000 kilowatts—could be made by a single fusion power station.

Waterfront site puts it near fuel and coolant supplies. One refinery separates heavy water from river, converts that to deuterium. Second plant extracts tritium "bred" by reactor. Deuterium-tritium mixture burns in reactor, making steam for dynamos. For close-up of works, please turn page.

Such a fusion reactor couldn't blow up or go into a "runaway reaction" as a fission plant can, since its fuel would be injected a little at a time instead of all at once. And, best of all, it would produce no radioactive "ash" to poison people, crops, and wild life. Present fission plants, by contrast, produce ashes that are very dangerous unless confined at great expense—one of the gravest problems of the infant atomic fission industry. In short, the whole prospect seems so alluring that the natural question is: What are we waiting for? After hearing this question a few times, one young physicist, who has bloodied his nose against some stubborn facts, made an ironic sign for his lab that read: "All You Have to Do Is—"

But the simplicity ends the moment you try to build such a reactor. Scientists began work on the problem about 10 years ago. The AEC has spent about 125 million dollars on the project, and plans to continue spending about 25 million dollars a year. U.S. firms and universities have spent additional sums, and the combined projects of Britain, Russia, Ger-

many, France, Sweden, Switzerland, and Japan are said to total twice the American effort. Some 40 experimental fusion devices of various sizes and design have been built and tested. Scientists have learned a lot about what *can't* be done and less about what *can*.

"Once it looked simple," said Dr. Richard F. Post, lean young fusion pioneer of the University of California Radiation Laboratory. "You heat a little deuterium gas in an evacuated chamber to 100,000,000 degrees or so, the reaction starts, you keep on feeding in more gas, and you have the source of power for all time. But we soon discovered that if anything can go wrong, it will." Every time one question is answered, more pop up.

One problem of the H-bomb tamers recalls the predicament of the young chemist who tried to invent a "universal solvent," then wondered what he would keep it in. If you heat deuterium hot enough for the atoms to fuse, no material container will hold it. Tungsten, for instance, the world's most heat-resistant metal, melts at 3,440 degrees Centigrade.

In the sun's nuclear fusion plant, the

force of gravity acts as the furnace wall. Since scientists can't build a sun-size reactor, they have adopted another invisible barrier—a magnetic field that cages the hot fuel and keeps it away from the metal reactor shell. In a sense, it does the job of the heat-resistant brick lining used to insulate furnace fireboxes. Already, temperatures of 10,000,000 degrees have been reported in such experimental reactors, and scientists hope that this intangible lining will provide the necessary container.

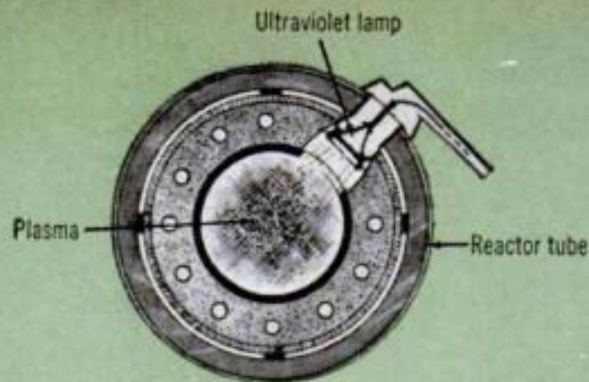
These magnetic bottles, or "cages," have been made in many designs in laboratories all over the world. But they are driving scientists crazy with their erratic behavior. Their walls have holes in them through which particles may escape. Said Dr. Edward Teller, sometimes referred to as senior statesman of thermonuclear fusion:

"It's as though the walls and ceilings of this room were lined with a layer of water held in place by pressure. If you disturb it, globules will break loose, and soon the lining will collapse."

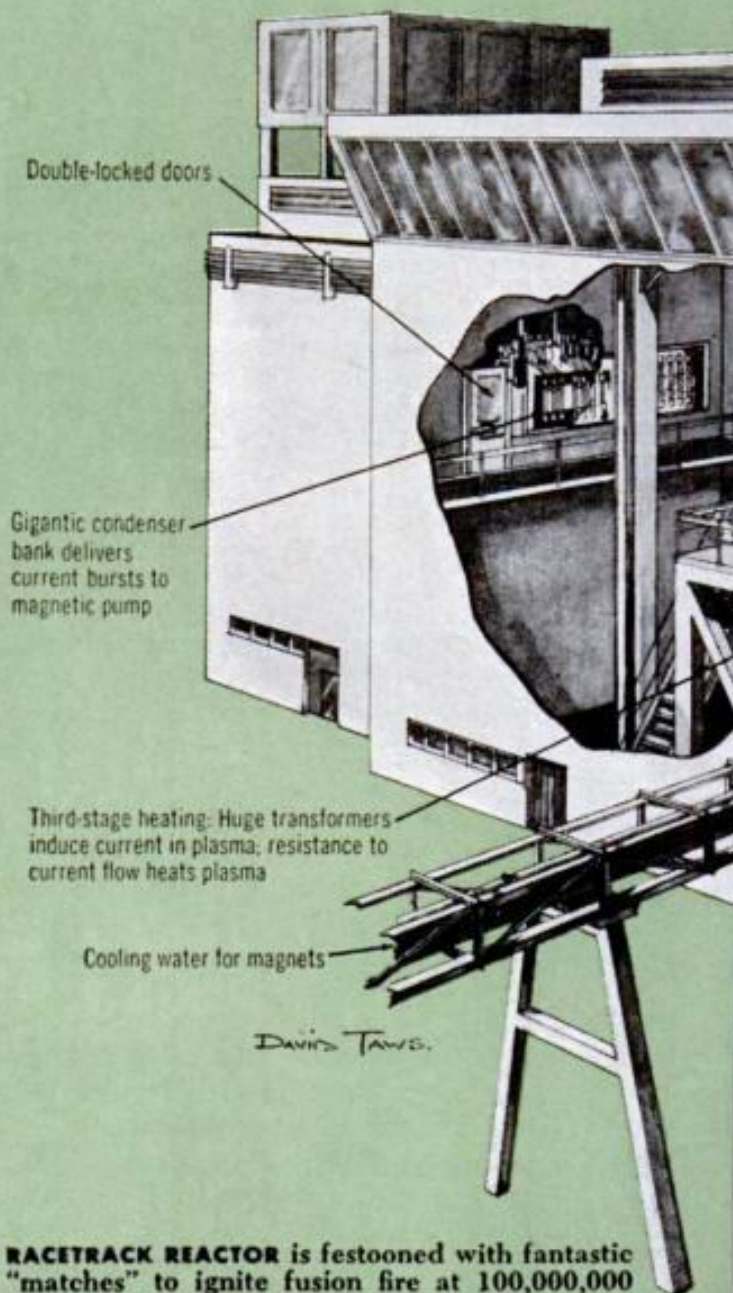
If this happens, the fuel will cool off, ruining the reaction. Or a small kink may develop in the magnetic cage. Like the wobble of a spinning top, it grows rapidly once it starts and the reaction stops. This has been a problem with all reactors, and a Russian physicist at the Geneva conference two years ago proposed a toast "to stability." Devices of many types have been built to prevent the wobble, and Dr. Teller reports that one machine in California has solved the problem.

There are many other headaches. In order to smash the deuterium atoms together hard enough to fuse them, you first have to peel off their outer shells of electrons to get bare nuclei; otherwise they cannot be forced close enough together to fuse. The actual fuel, therefore, is an ionized gas called a "plasma"—one of the key words of the whole campaign. About 99 percent of the universe is composed of such plasma—the sun, the stars, and much of space. It makes up the ionosphere. The conducting gases in neon and fluorescent lamps are plasmas, and they have been used for years in several electronic tubes. Many scientists are studying the whole nature of this fourth state of matter as an initial step to the

[Continued on page 240]

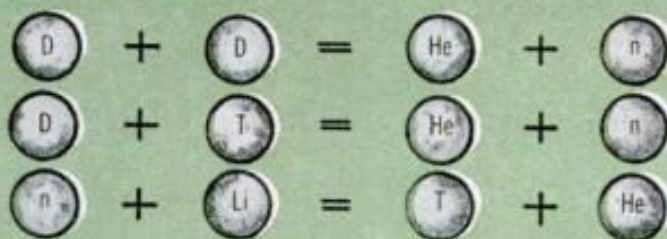


First-stage heating: Ultraviolet light ionizes deuterium and tritium into plasma, peeling off electrons to leave electrically charged nuclei of atoms



RACETRACK REACTOR is festooned with fantastic "matches" to ignite fusion fire at 100,000,000 degrees. It makes part of its own fuel—neutrons from reaction transform lithium into tritium. This type—Stellarator—would generate electricity by making steam, like oil furnace. Others might convert fusion energy directly to electricity. This is an artist's conception.

Two fusion reactions merge atomic nuclei to produce new kind of nucleus (helium) and neutron. Loss of weight is transformed into speed of neutron. This becomes heat when water (in steam tubes) slows neutron. Third reaction generates fuel by using some neutrons to split lithium into tritium and helium.



Plasma
Fourth-stage heating: Magnetic pump uses rapidly reversing current in coils to compress and expand plasma. Gases heat when compressed. This device should bring plasma to 100,000,000-degree fusion point

Second-stage heating: Alternating electric field increases ionization of plasma

Spark-gap switch

Control room

Power for heating transformers

Vacuum pumps

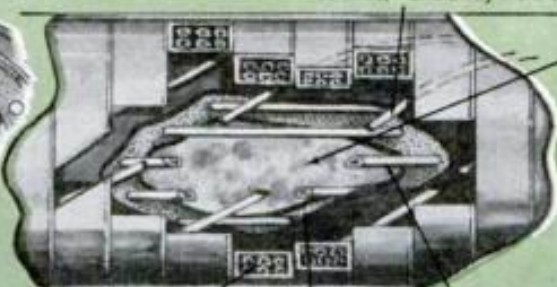
Diverter skims off plasma particles that get too close to tube wall. It alters magnetic field so that outside lines of force curve out into trap, carrying maverick particles with them.

Supporting framework of thick stainless-steel plate

Corkscrew coils make magnetic lines of force spiral. This keeps plasma particles twisting around lines of force (like rope strands)—and away from tube wall

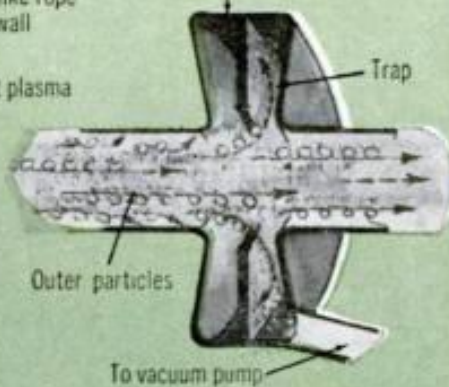


Water-cooled coils generate magnetism that squeezes plasma toward center of tube



Blanket of lithium

Steam tubes



Trap

Outer particles

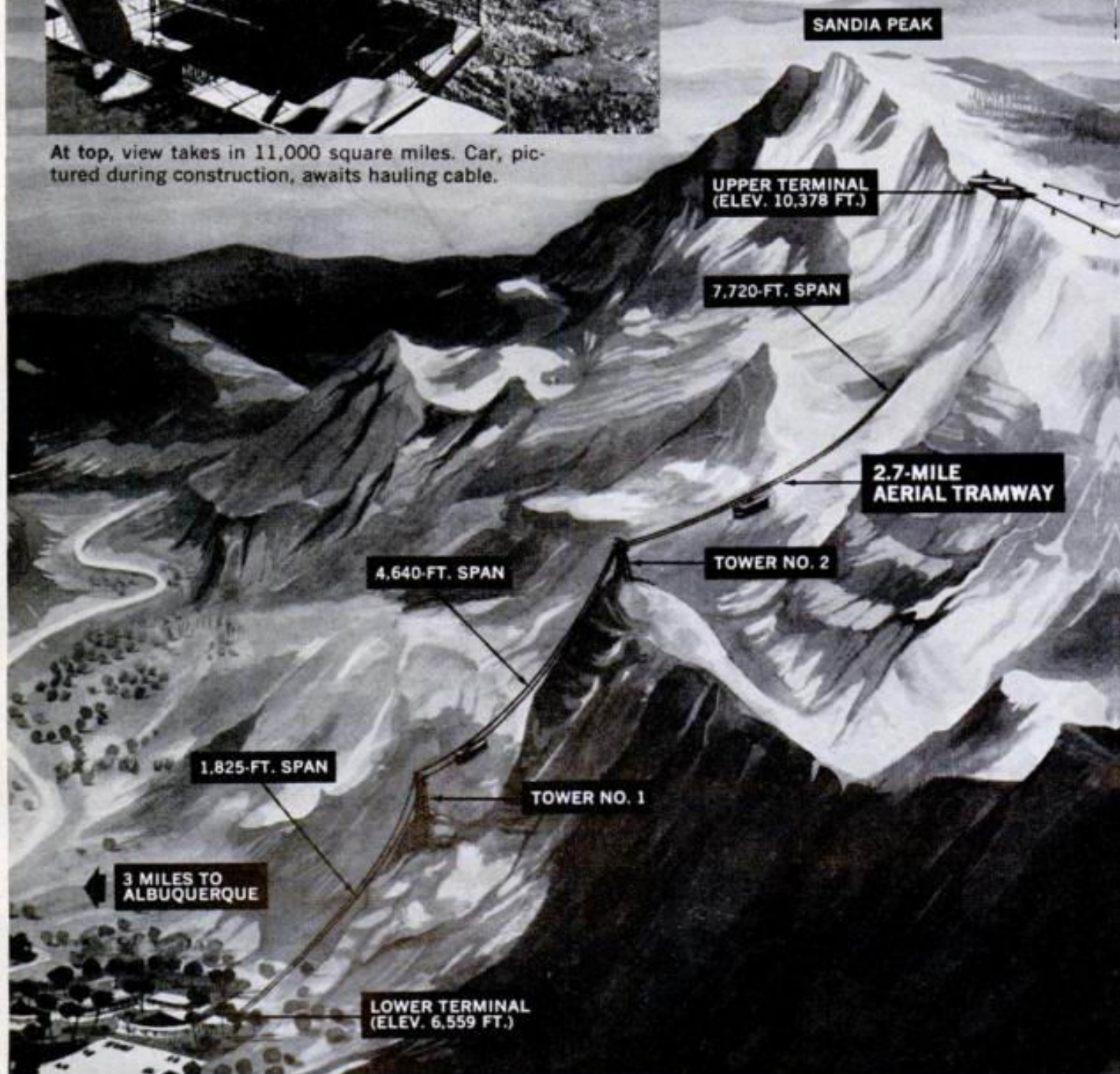
To vacuum pump

World's

Sky cars give passengers



At top, view takes in 11,000 square miles. Car, pictured during construction, awaits hauling cable.



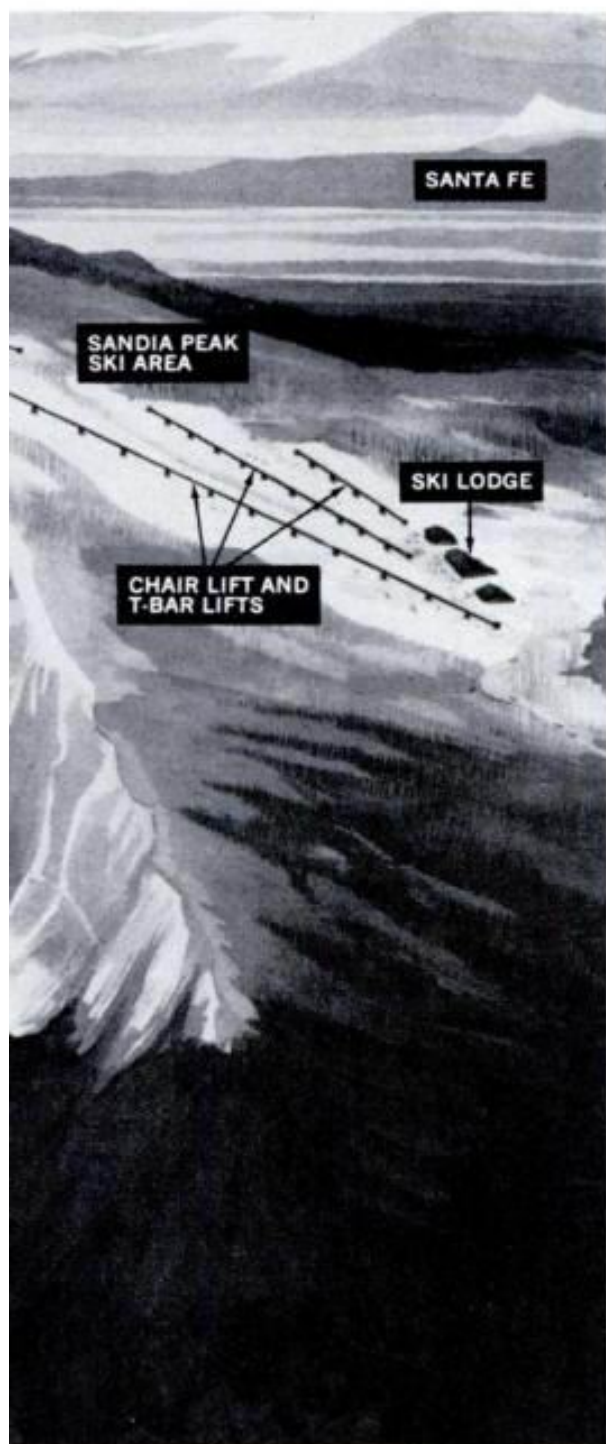
Sixty-passenger cable cars give a thrilling 10-minute sky ride to a ski playground atop a scenic mountain, on the newly opened Sandia Peak Aerial Tramway in New Mexico. At its upper terminal, a restaurant-and-lounge building commands a breathtaking full-circle view of 11,000 square miles.

The 2.7-mile line sets a world record in length for one of its "jigback" type—a two-car tramway on

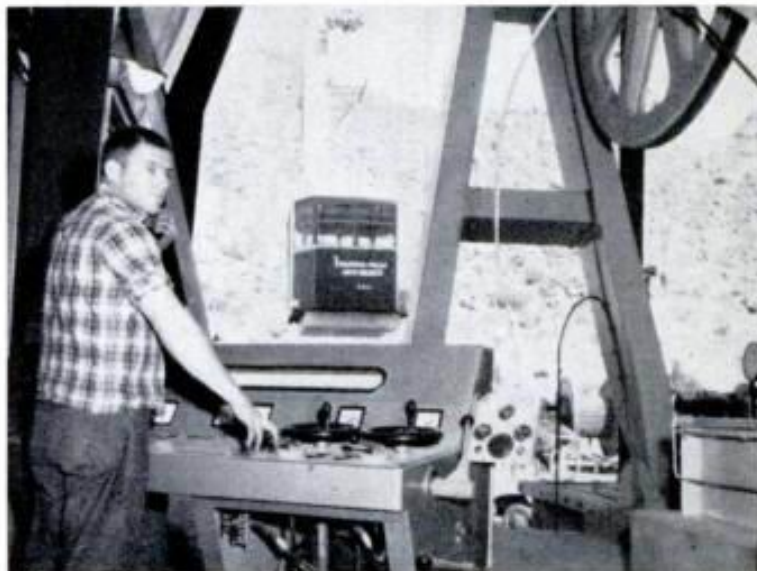
which one car ascends as the other comes down. Its track, supported by two towers along the way, consists of two pairs of $1\frac{5}{8}$ -inch cables. These are anchored at the upper end in rock, and at the lower end in 90-ton concrete counterweights that maintain even tension regardless of the cars' movements. A separate and endless hauling cable, driven by an 850-hp. motor, propels the cars at up to 17 m.p.h.

Longest "Jigback" Aerial Tramway

an exciting 2.7-mile trip to a ski playground atop a New Mexico peak



Shown in the drawing above are the tramway's setting and principal features, including a swoop of 7,720 feet between Tower No. 2 and the upper terminal—a clear span exceeded in length only on one aerial tramway in France and one in Venezuela. Accompanying photos were made during construction of the line.



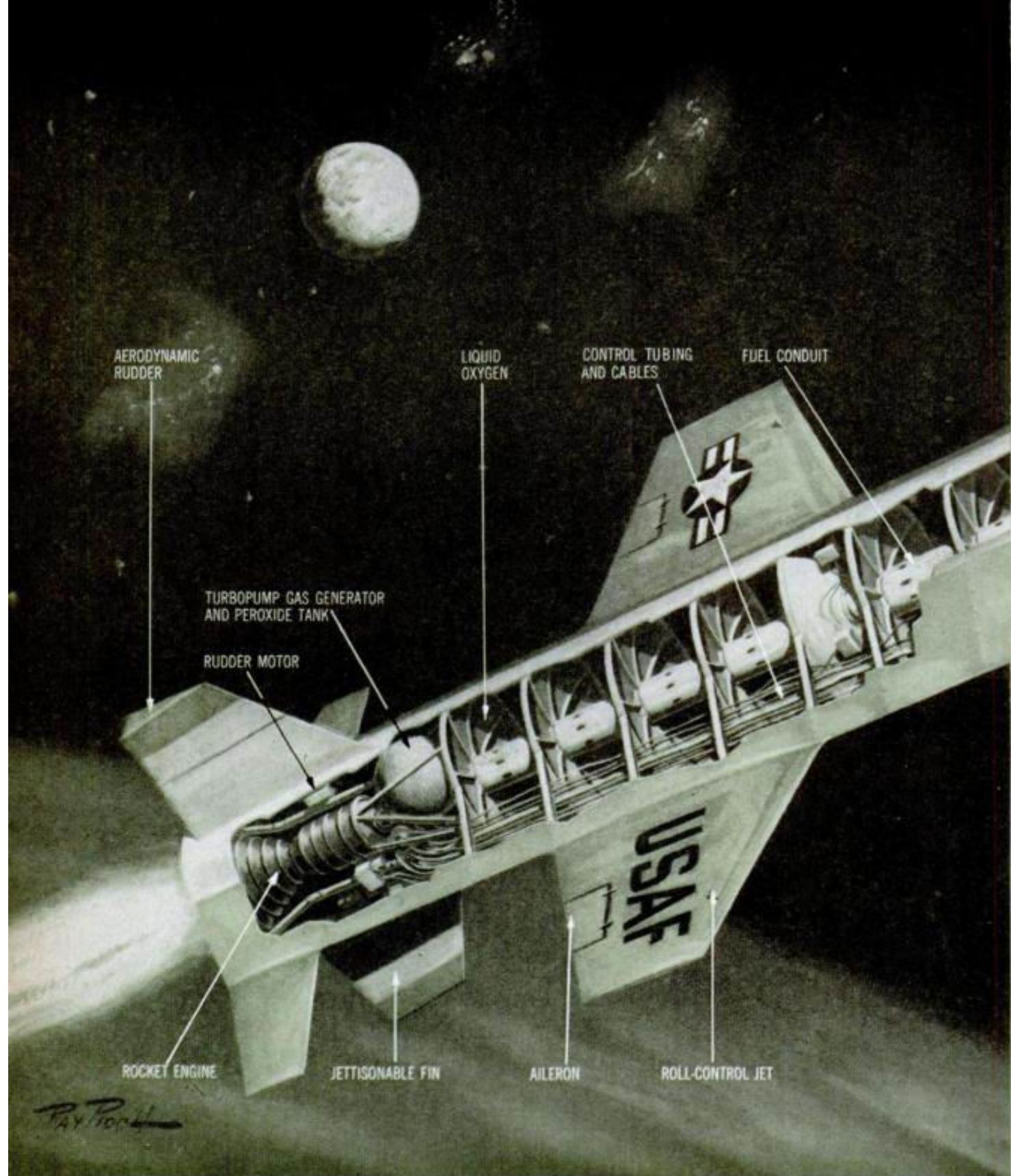
Control panel, in lower terminal, operates endless hauling cable that raises one car and lowers other. Operator can talk by phone with an attendant riding in each of the cars.



"Leaning tower," No. 1 of tramway's two, slants 18 degrees from vertical for most effective bracing. Man near top is standing erect. Members above him support track cables, not yet installed in this construction view.



Massive counterweights of concrete, hanging on lower ends of track cables in 70-foot-deep pit, rise and fall to maintain even tension as cars move. Two of the four 90-ton counterweights are seen in the photograph above.

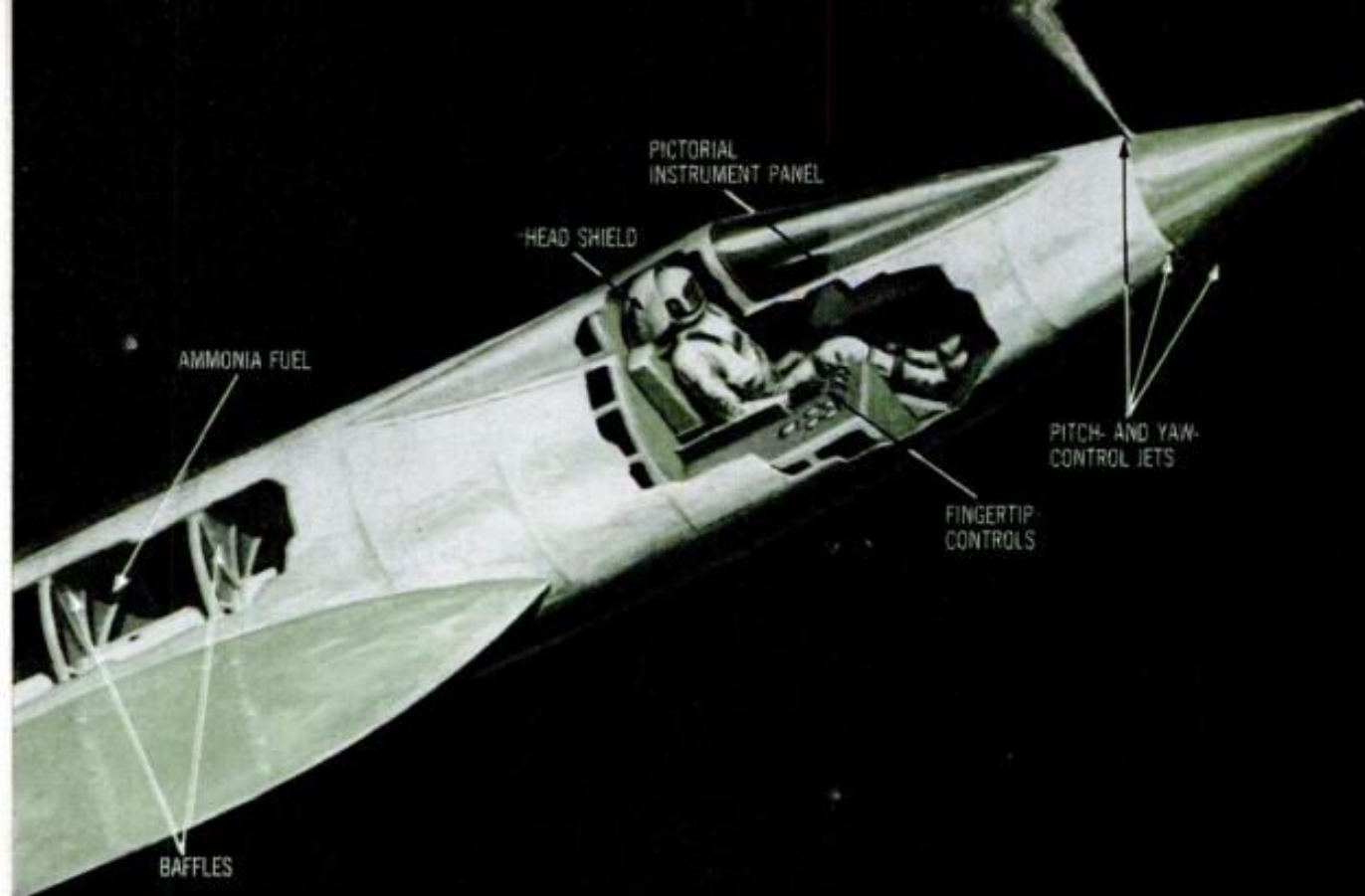


A stubby-winged "missile with a cockpit," the X-15 will take its pilot to the edge of space—and open a new era of flight

By Wesley S. Griswold

THE most extraordinary airplane in the U. S., and probably the world, is now taking shape in a closely guarded Los Angeles factory.

The X-15 is a research craft as far in advance of today's hottest fighters as they, in turn, exceed the Wright Brothers' powered box kite. It is intended to fly scores of miles higher and at least 2,000 m.p.h. faster than any plane now in the



Mile-a-Second Rocket Plane Will Fly 100 Miles High

sky. The men who first fly it will take a tentative dip in the mysterious sea of outer space before future men plunge in.

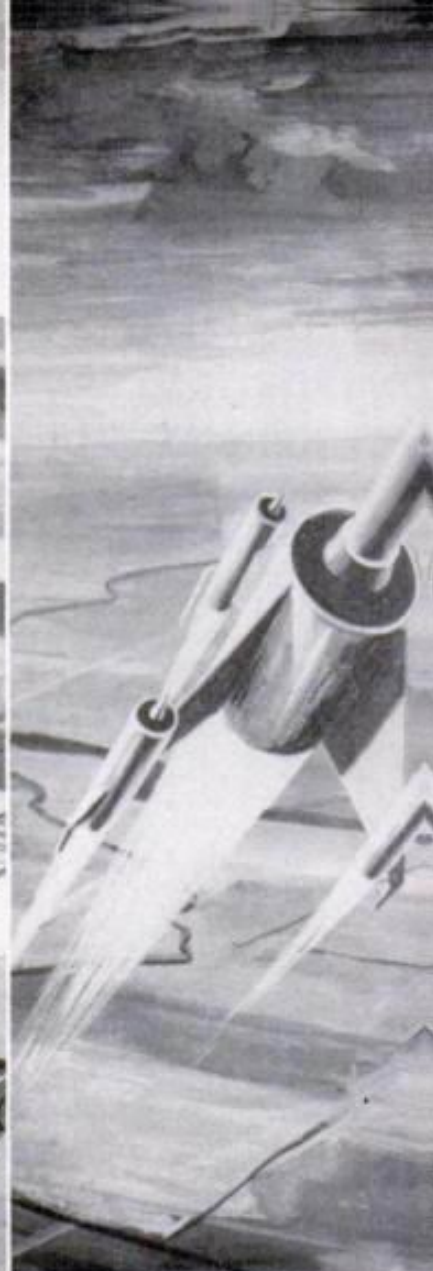
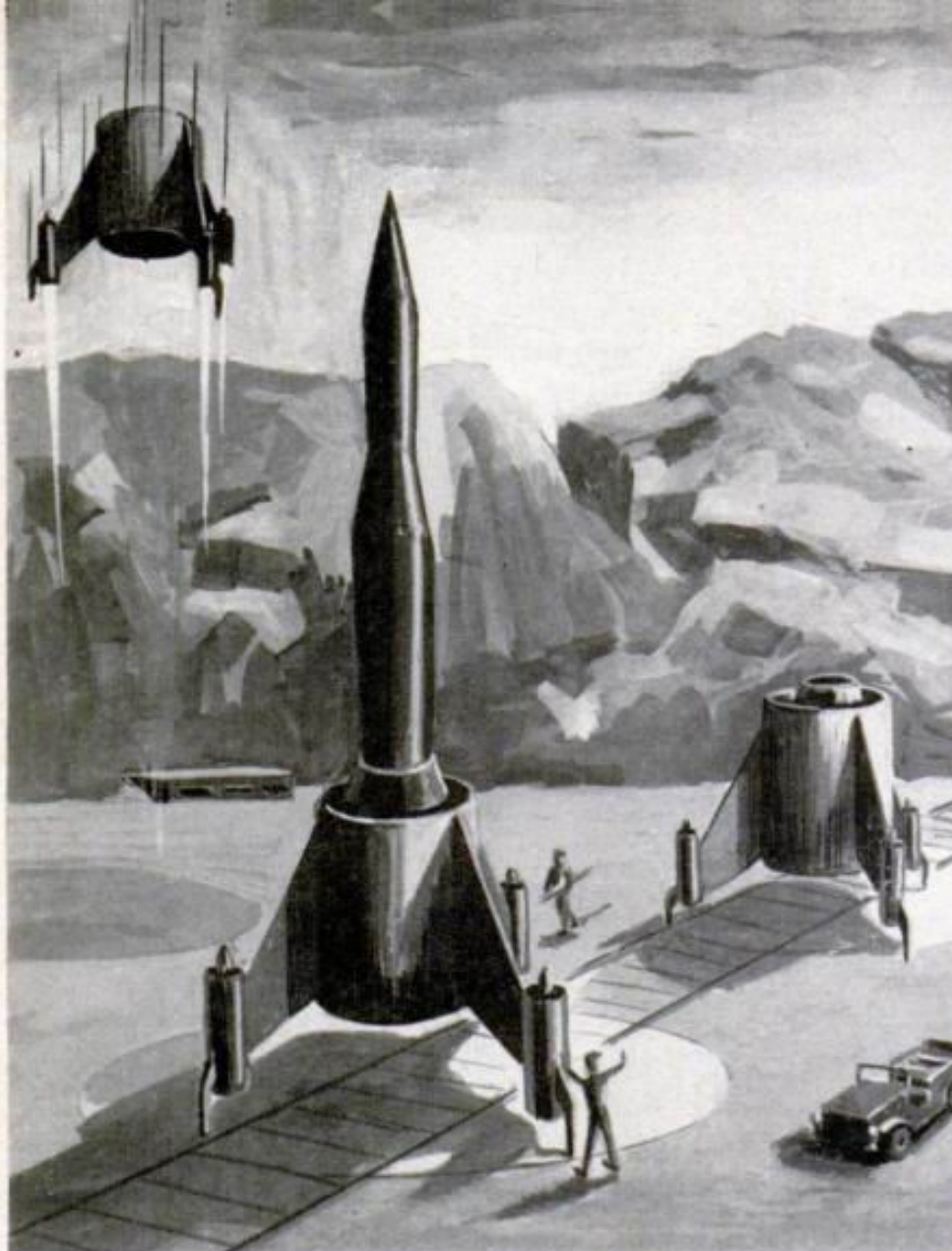
Still months away from trying its stubby wings, the revolutionary X-15, a manned rocket ship, has already stirred international excitement.

It has been grandly heralded as "a steppingstone to the stars." But the men

who designed it, the technicians who are building three of it, and the test pilots at Edwards Air Force Base who will find out just how high and how fast it can go have less poetic names for this up-and-coming wonder. They call it "the flying fuel tank" or "the missile with a cockpit."

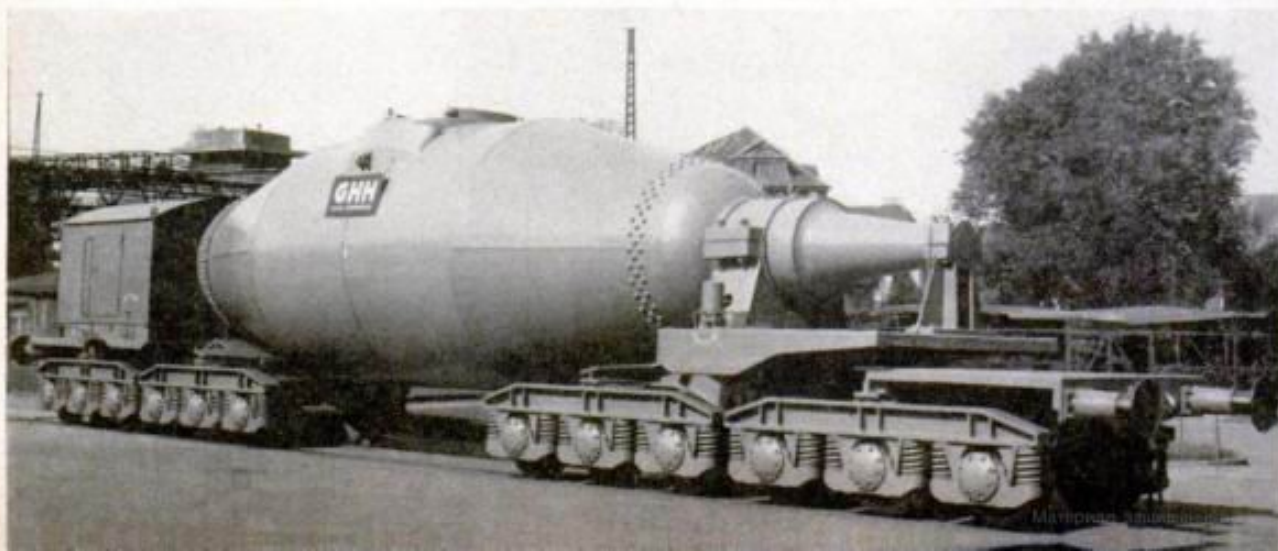
Only one official statement has been made so far about what the X-15 will do,

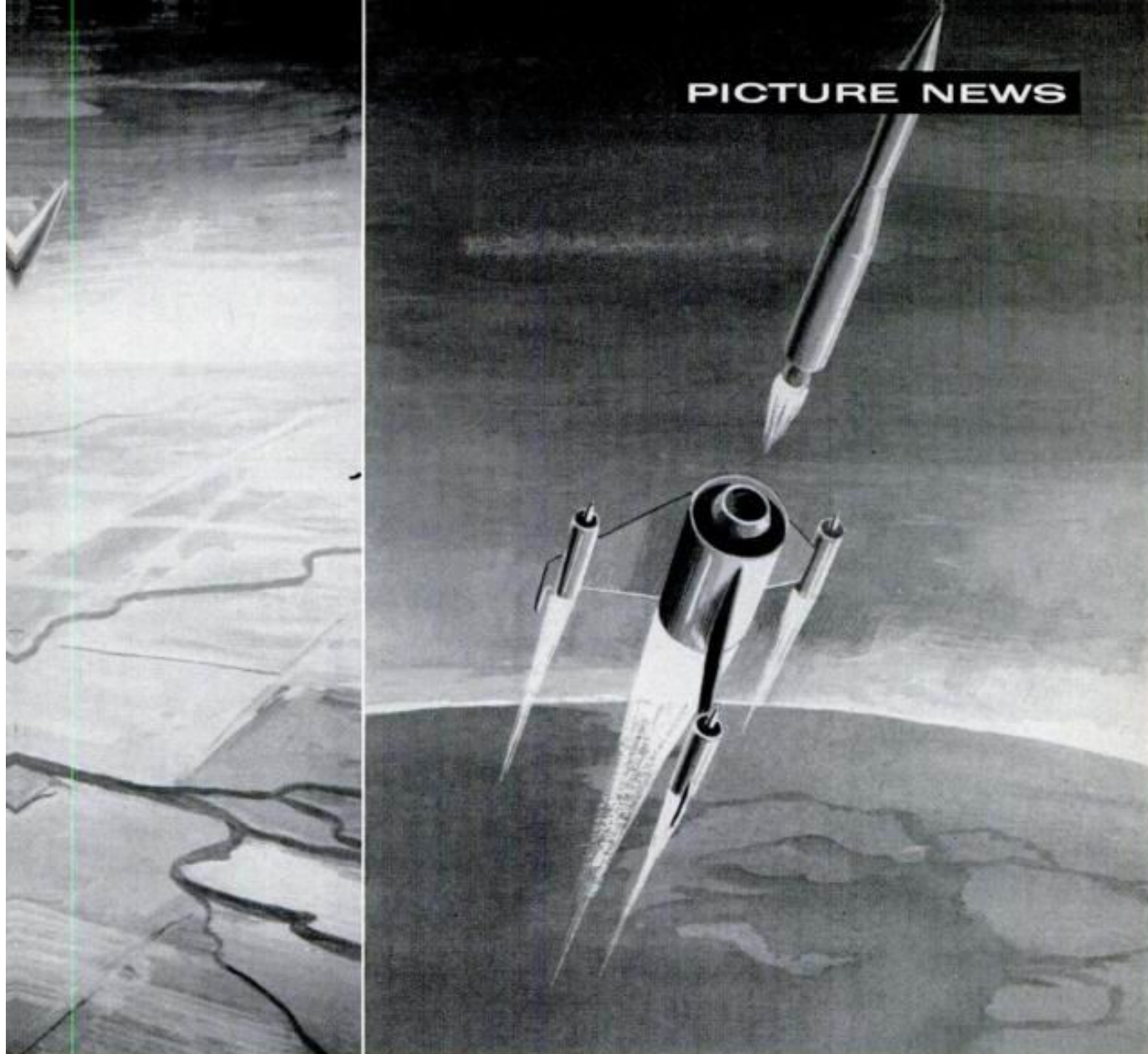
JUNE 1958 III



Jets to aid rocket launching? An ingenious new way to kick off missiles and space vehicles has been proposed by General Electric engineers. Jet engines, in effect a new first stage, would boost a missile up many thousands of feet before the missile's own rocket engines began

Rail car transports molten metal. This odd-shaped tank car slung between two pairs of three-axle trucks is used by the French State Railways to haul liquid pig iron from blast furnaces to steelworks in the Ruhr. It picks up its load at several smelting plants, rotates to discharge it through the opening at top. German made, it can hold 150 tons.





firing. Efficiency would increase because the jets, being air-breathing, wouldn't have to carry their own oxidizer. Other advantages claimed: The jets would be recoverable, and launching sites could be simpler. Shown above are three phases of the launching operation.

Ferry rides on water jets. No propeller or rudder is needed on the craft below. It travels on water sucked in by diesel and shot through ports at bow and stern. Two levers operate valves controlling flow to port and starboard. With one forward and the other back, it turns on its axis. It is run in Uganda by unskilled African crews, can carry a 10-ton truck.

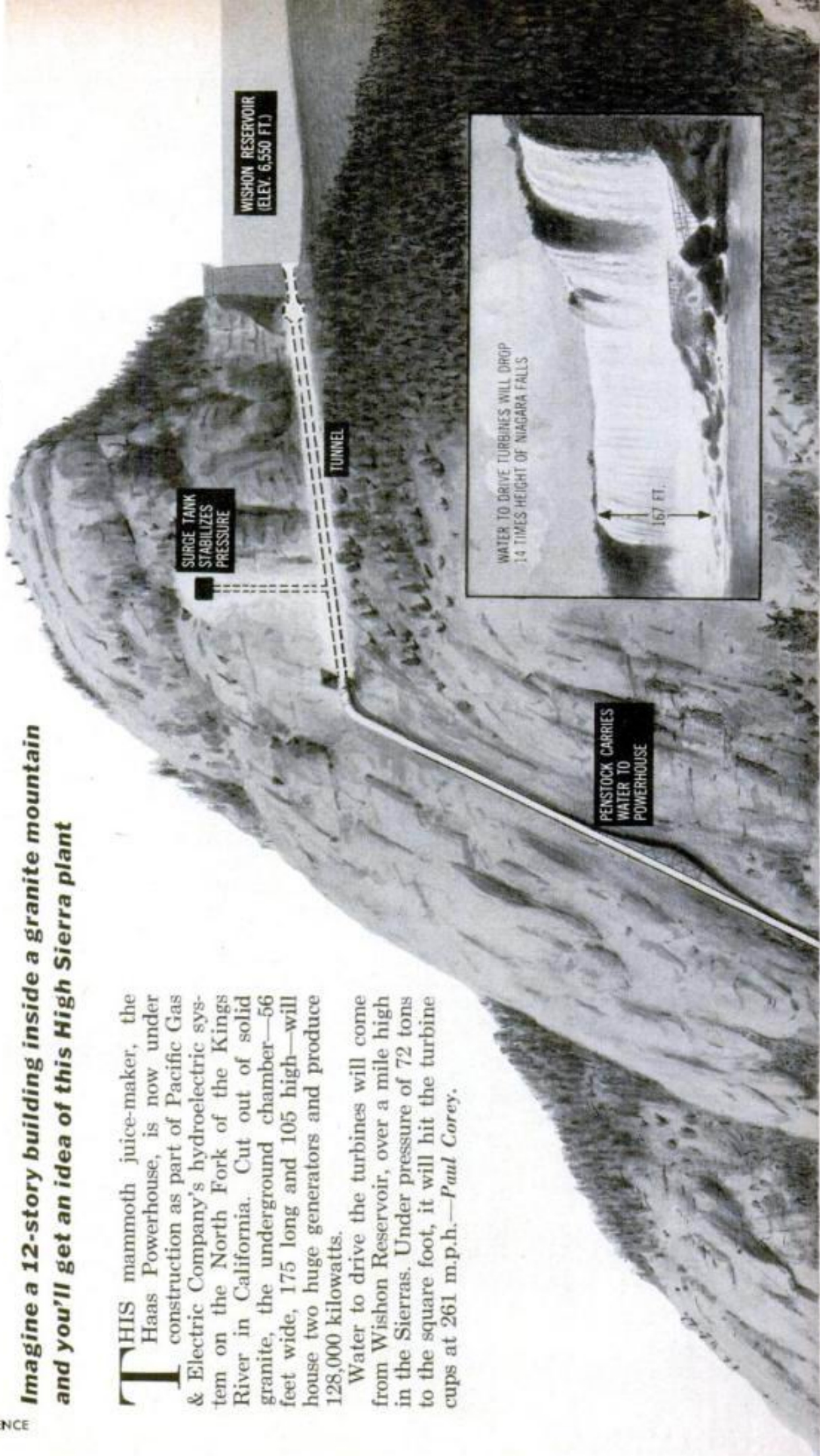


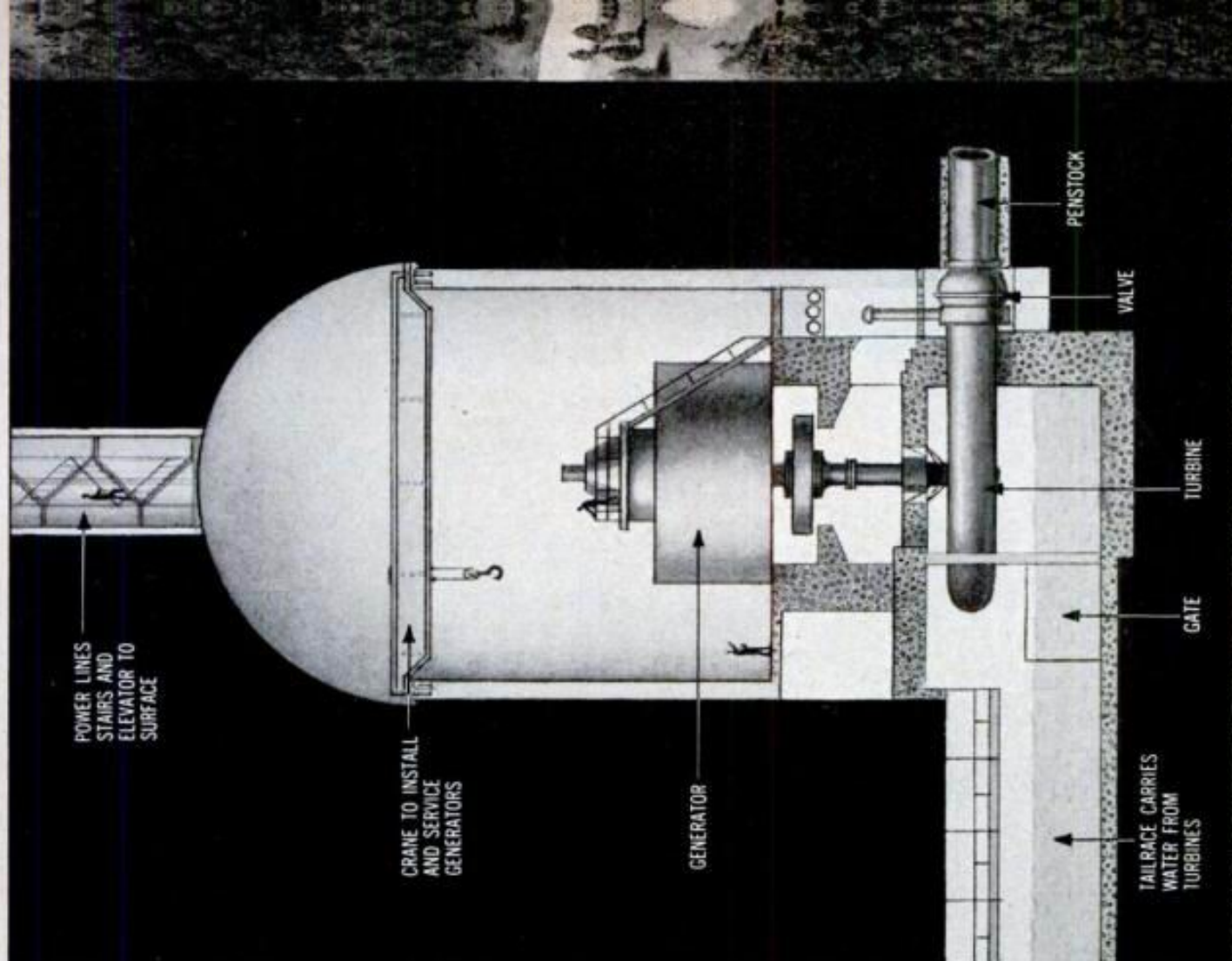
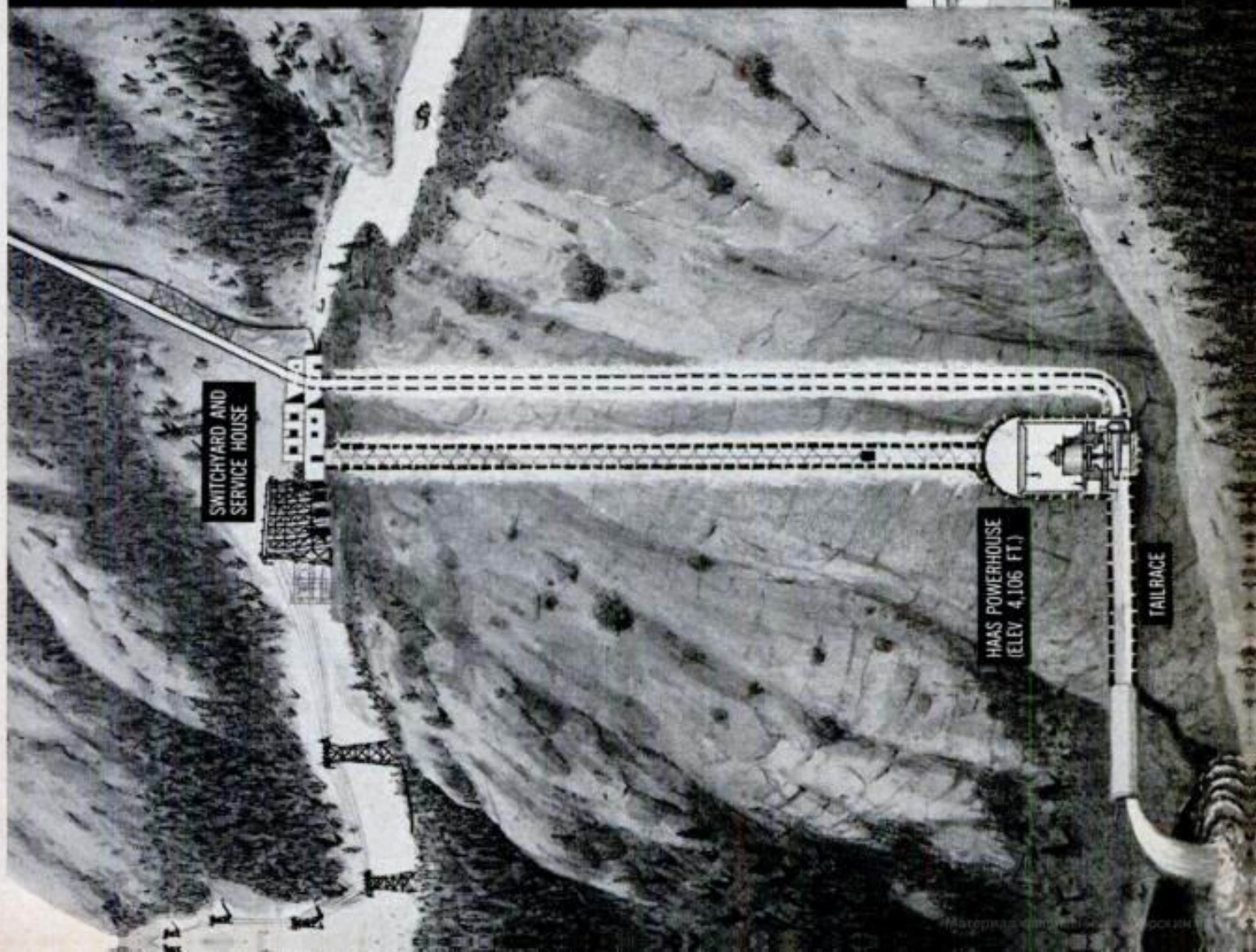
Building a Giant Powerhouse 500 Feet Underground

Imagine a 12-story building inside a granite mountain and you'll get an idea of this High Sierra plant

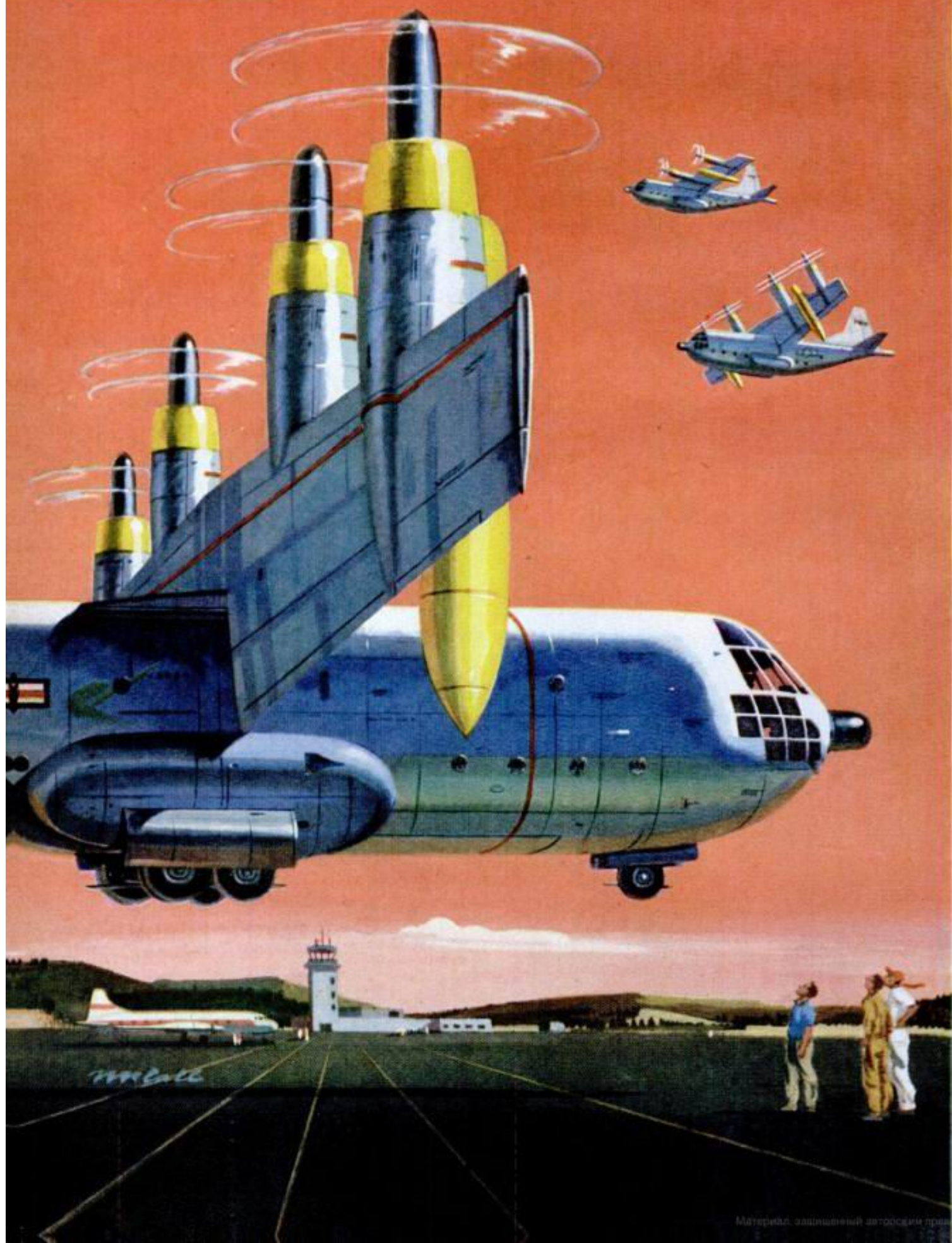
THIS mammoth juice-maker, the Haas Powerhouse, is now under construction as part of Pacific Gas & Electric Company's hydroelectric system on the North Fork of the Kings River in California. Cut out of solid granite, the underground chamber—56 feet wide, 175 long and 105 high—will house two huge generators and produce 128,000 kilowatts.

Water to drive the turbines will come from Wishon Reservoir, over a mile high in the Sierras. Under pressure of 72 tons to the square foot, it will hit the turbine cups at 261 m.p.h.—*Paul Corey.*





**POPULAR
SCIENCE**
REG. U. S. PAT. OFF. *Monthly*



350-M.P.H. Tilt-Wing Transport to Rise Like a Copter



With props pointing skyward, it would be a whirlybird for takeoff and landing, then become an airplane for forward flight.



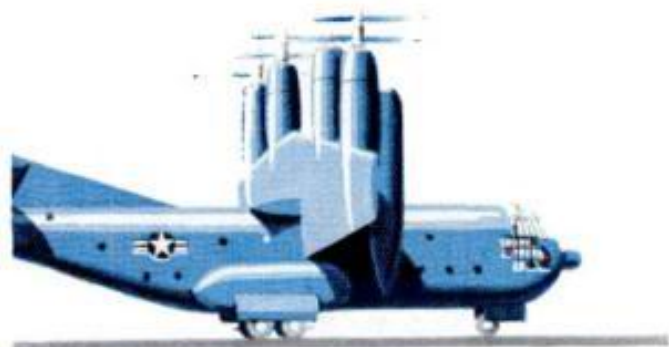
By Wesley S. Griswold

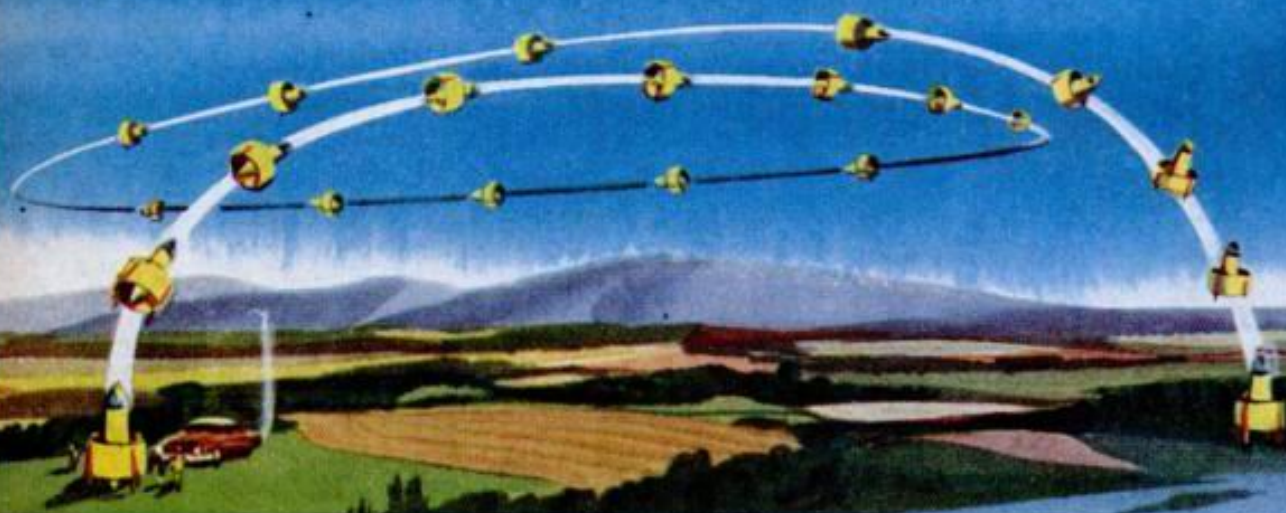
THE aircraft company that cooked up the "flying piepan" now has designed for the U. S. Army a big air transport that will go straight up like a copter, then streak away like a DC-7.

It's not a helicopter. It's not an airplane, as such. Yet it's both. The tilt-wing Propelloplane, as this extraordinary craft is called, was designed by Hiller Helicopters of Palo Alto, Calif. It would carry 40 to 50 fully equipped troops, or several small vehicles, or a big load of military supplies many hundreds of miles at nearly three times the speed of the fastest helicopter. Yet it would be able to pick up and set down its cargo on any small, flat patch of ground. It would cruise at 350 m.p.h., but land at zero m.p.h.

This versatility would be accomplished by an otherwise conventional wing that would tilt 90 degrees for vertical, straight-up-or-down, takeoffs and landings. Tilting with the wing would be four large, six-blade, contrarotating propellers and their high-powered turboprop engines.

Drawings, based on an exhaustive study made under contract for the Army, indi-

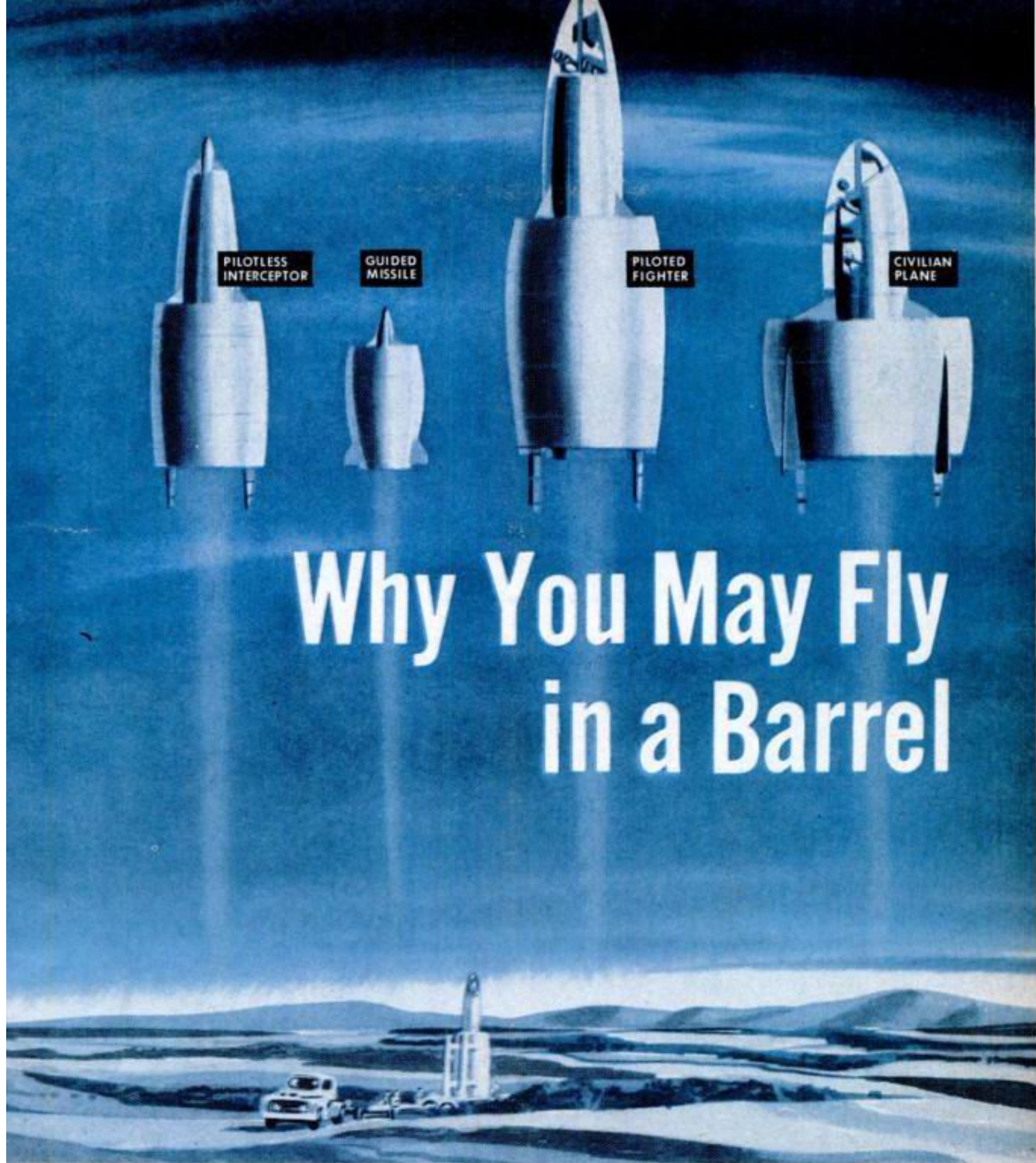




Artist shows coleopter in level flight and, in diagram below, ascending and landing vertically.

Tomorrow's plane, say designers in France, will be a flying engine with a wing wrapped around it.

By Alden P. Armagnac



Why You May Fly in a Barrel

Principle can be applied in variety of aircraft for many uses, as these four examples show.

THEY'RE hatching a sensational mechanical bird in an aeronautical laboratory at Brunoy, near Paris, France. Quivering in gales faster than sound, wind-tunnel models give the spectator an exciting preview of what may be to-

morrow's airplane. The barrel-winged craft looks more like a projectile.

It will take off straight up, like a rocket. Gradually it will level off into horizontal flight. Finally it will up-end itself once more, descend vertically, and alight,

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as it started, on its tail.

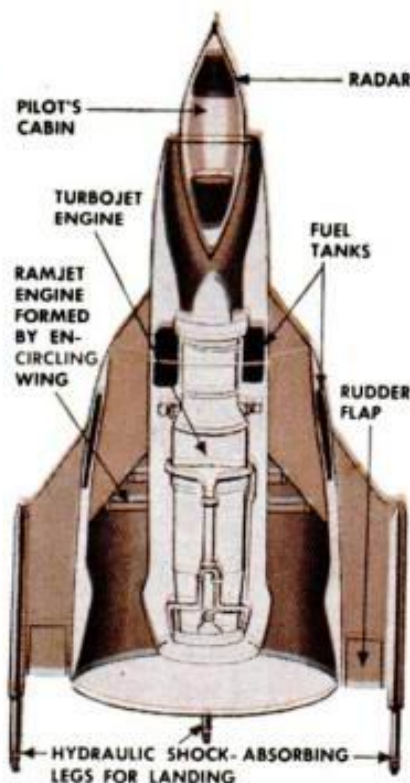
Under development by a French-German group of researchers, the fledgling craft is called a coleopter. An inexact but popular equivalent of its name would be "flying bug." It's a promising new member of the ultramodern family of aircraft designated by the magic initials V.T.O.—vertical take-off.

By matching both the vertical-rising ability of helicopters and the aerial performance of other types, V.T.O. planes would free aviation from dependence upon airport runways and carrier decks. Already the V.T.O. idea has inspired some of the most radical machines ever flown—America's tail-sitting "pogo" planes, England's fantastic "flying bedstead," and vertical-horizontal hybrids called convertiplanes.

But the coleopter, with its tubular wing, belongs in a class by itself. Finding nothing like it proposed before, France's Ministry of Industry and Commerce has granted more than a dozen basic patents for its design.

Bending its wing into a circle, its proponents explain, makes a single structural member do the work of two. The wing itself serves as the outer part of a jet engine, or as the duct of a ducted-propeller power plant. By saving weight, the range and payload are boosted. Moreover, a circular wing is strong, easily made and, since it is perfectly symmetrical, ideally maneuverable in the air.

For lift in level flight, a conventional plane's wing is mounted at a slight inclination to fuselage and air stream. The tubular wing, instead, is coaxial with the fuselage. So a coleopter supports itself by flying horizontally in kitewise fashion—the whole craft inclined a few degrees upward to the air stream. The



CUTAWAY VIEW of coleopter shows it is virtually a flying engine. Here, barrel wing forms ramjet, to supplement turbojet at center.

lift then corresponds to that of a biplane, whose span equals the diameter of the circular wing.

Coleopters will serve both military and peaceful purposes. Here are examples of projects on the designers' drawing boards:

A guided missile called the Ogre, some six feet long and three feet in diameter, carries a shaped-charge warhead. Its ramjet engine hurls it at 530 m.p.h. to an estimated tactical range of 30 miles.

A pilotless interceptor, the 17-foot Charencon VI, climbs in two minutes to its 65,000-foot service ceiling. A ramjet engine supplements its turbojet power plant to give bursts of 1,300 m.p.h. speed. Radar

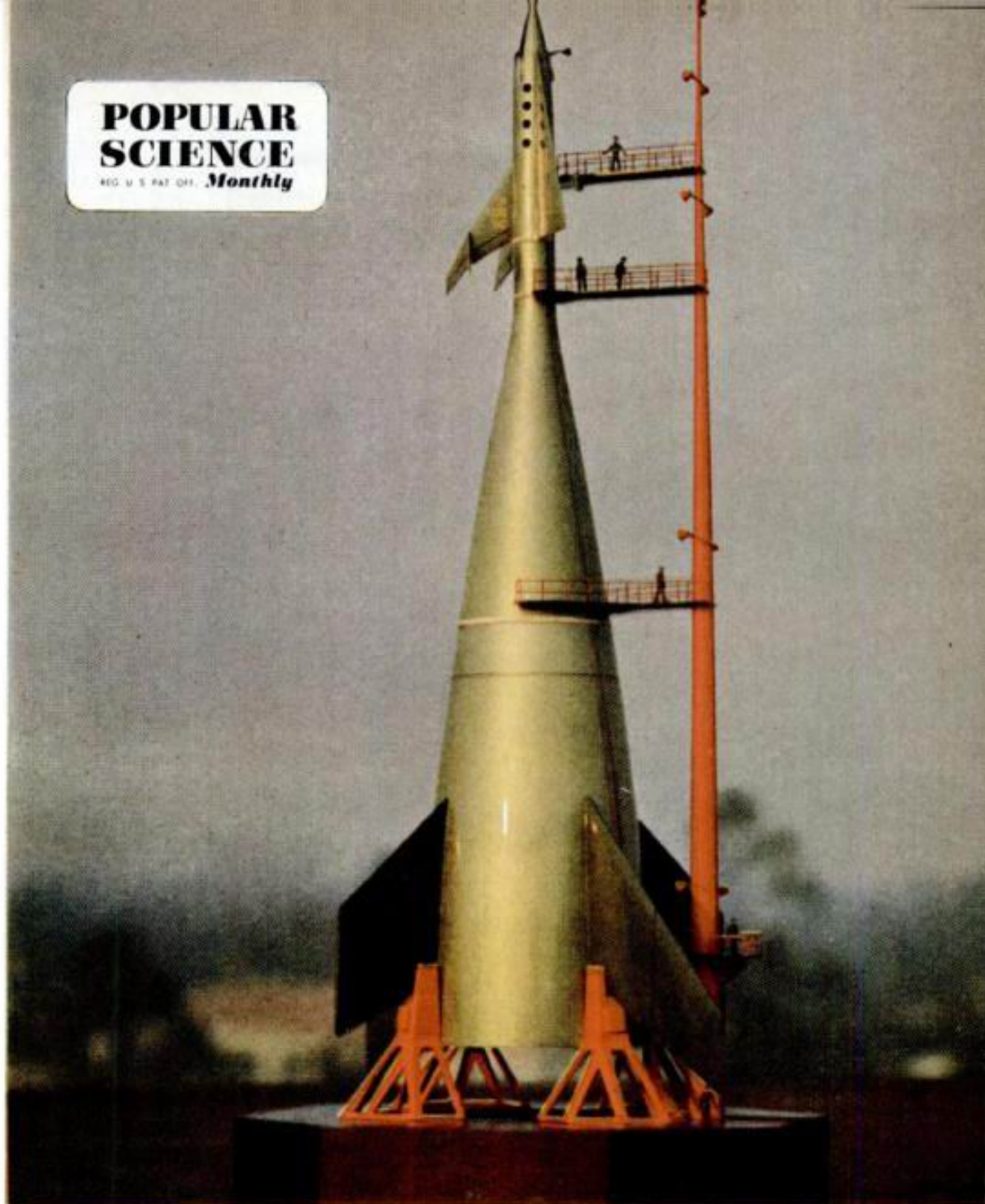
and a television eye guide it to the target, which it destroys with cannon fire or rockets. Then it returns to base.

A light ground-attack plane, the 27-foot Bruche, flies at 900 m.p.h. under the combined power of a turbojet engine with an afterburner, and a ramjet.

A touring plane, the three-seat Hannonet II, is 19 feet long and has a barrel wing 20 feet in diameter. Two turboprop engines drive tandem propellers, whose thrust is enhanced by the wing-formed duct around them. This 280-m.p.h. plane of 620-mile range would be fast and economical for private flyers.

Occupants of coleopters remain comfortably upright in swivel seats, whether in vertical or level flight.

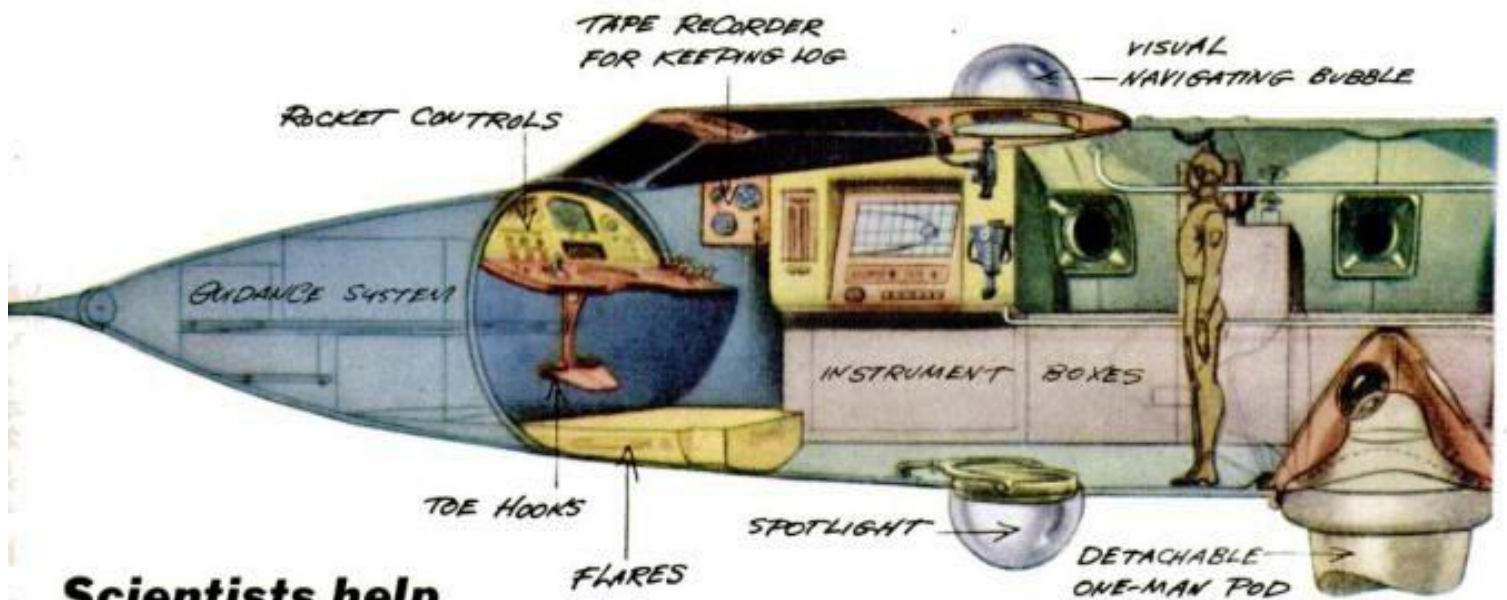
For short-to-medium-range air transport, the coleopter is the logical plane of the future, calculations convince a group of backers headed by Helmut von Zborowsky, Austrian-born engineer, and including Prof. Heinrich Hertel, former chief of development at Germany's great Junkers works. Participating with them in developing the coleopter is France's largest aero-engine concern. **END**



Disney Plans TV Trip to the Moon

FAR bigger and more elaborate than the "flying basketball" with which the U.S. plans to dip its toe into outer space a couple of years from now, is the space station from which Walt Disney intends to take his TV watchers on an inspection trip to the moon some Wednesday evening in December. The "Disneyland" (ABC-TV) program that night will be called "Man and the Moon." It will consist of a film with both live action and

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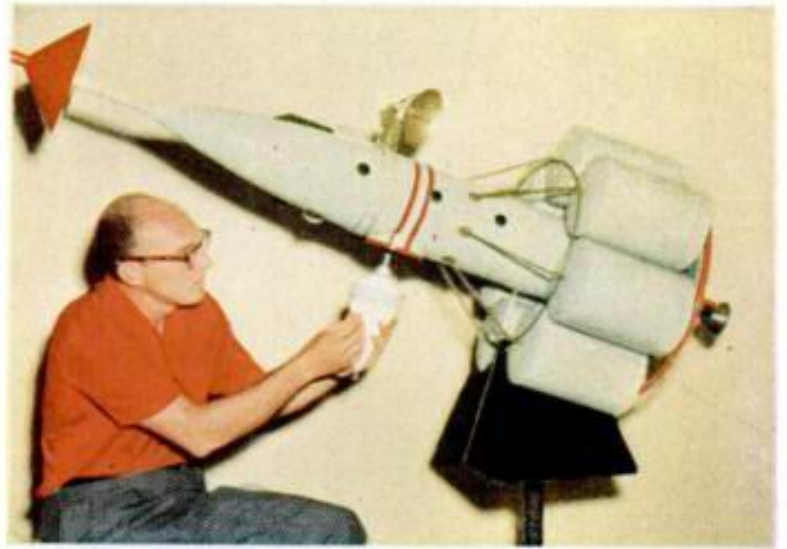


Scientists help artists design spaceship

Rocket dreamed up for Disney's TV show

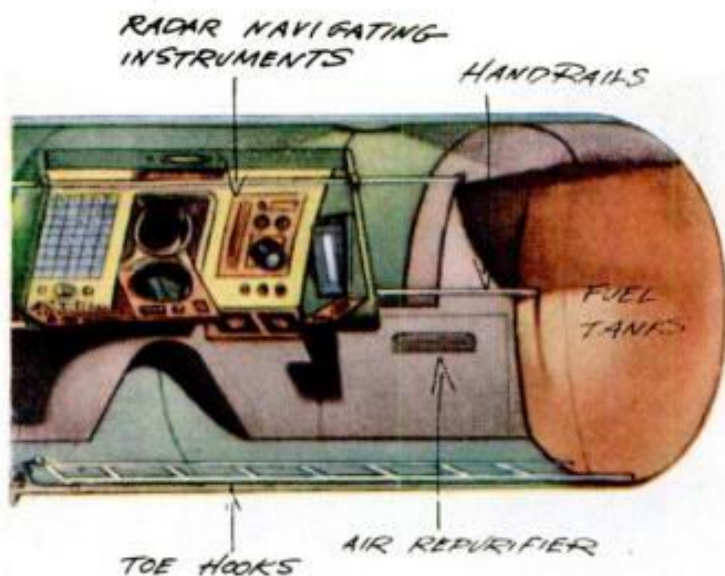
animation, and its theme will be an imaginary, two-stage journey to within 60 miles of our biggest natural satellite, customarily 240,000 miles away.

The imagination will be based on a high degree of probability, for Dr. Werner von Braun, chief of the Guided Missile Development Division of the Army's Red Stone Arsenal, and rocket experts Dr. Heinz Haber and Willy Ley were technical advisers for "Man and the Moon." Scenes pertaining to the filming are shown here.—Wesley S. Griswold.



No-gravity is a problem (below) as a man is stuffed into a detachable pod (above) for





would be 53 feet long and carry four men.



a side trip to the permanent space station.

THE SPACE STATION, shown in the model below, is wheel-shaped, 200 feet across, and houses 50 men. Small rocket motors set it twirling slowly to create artificial gravity inside.

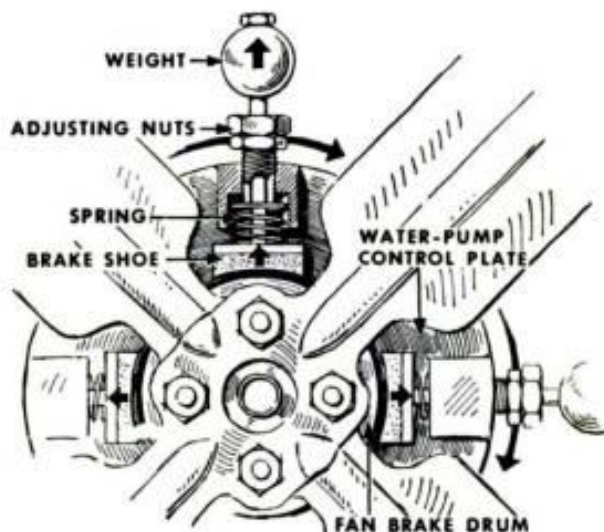


Part-Time Fan Cuts Car Noise

SOME 400 Midwest motorists are driving around these days in cars whose fans have been doctored to shut off when they get up to a speed of around 40 m.p.h.

The doctoring was done by a Franklin, Ind., car dealer and mechanic. Pete Keeling, who gets his patented Kee-Darr fan cutouts made by a local machine shop and installs them himself at a total cost of about \$40.

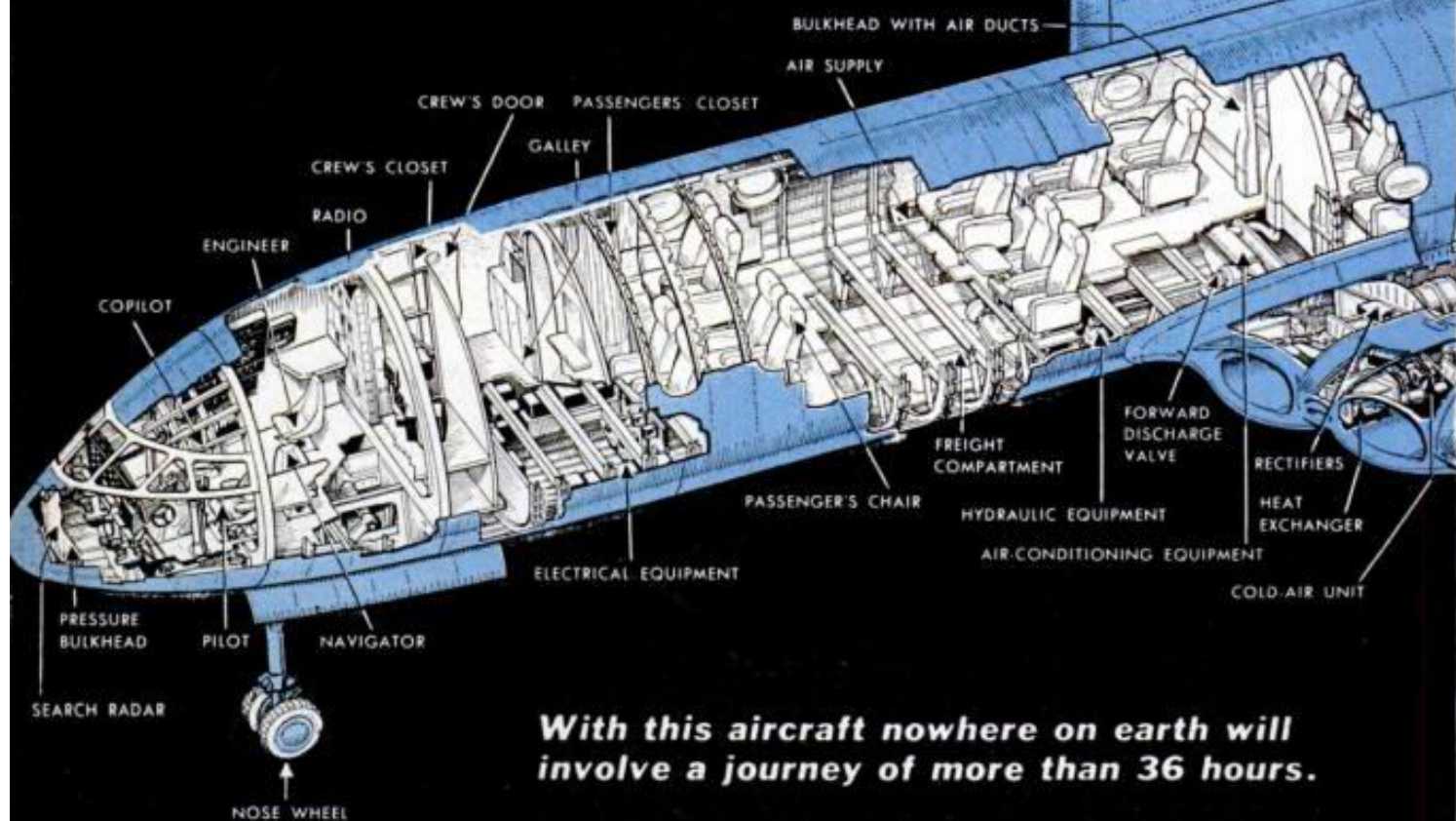
At highway speeds, Keeling explains, enough air blows through a



car's radiator to keep the engine cool, so long as the water pump keeps going. Keeping the fan chewing at the air stream only wastes gas and makes unnecessary noise.

Keeling's kit, which fits most 1954 and '55 cars, disconnects the fan when the engine hits 2,000 r.p.m. (about 40 m.p.h.), but keeps it spinning at slower speeds. The fan blades are attached to a brake drum that can spin free on the water-pump shaft. Fastened to the shaft is a control plate carrying four brake shoes. At low speeds the shoes grip the drum, and the fan turns with the pump. At high speeds, centrifugal force pulls the brake shoes outward, releasing the fan—and, Keeling says, saving six to 16 hp.

New Comet Designed to Cruise at 500 M.P.H.

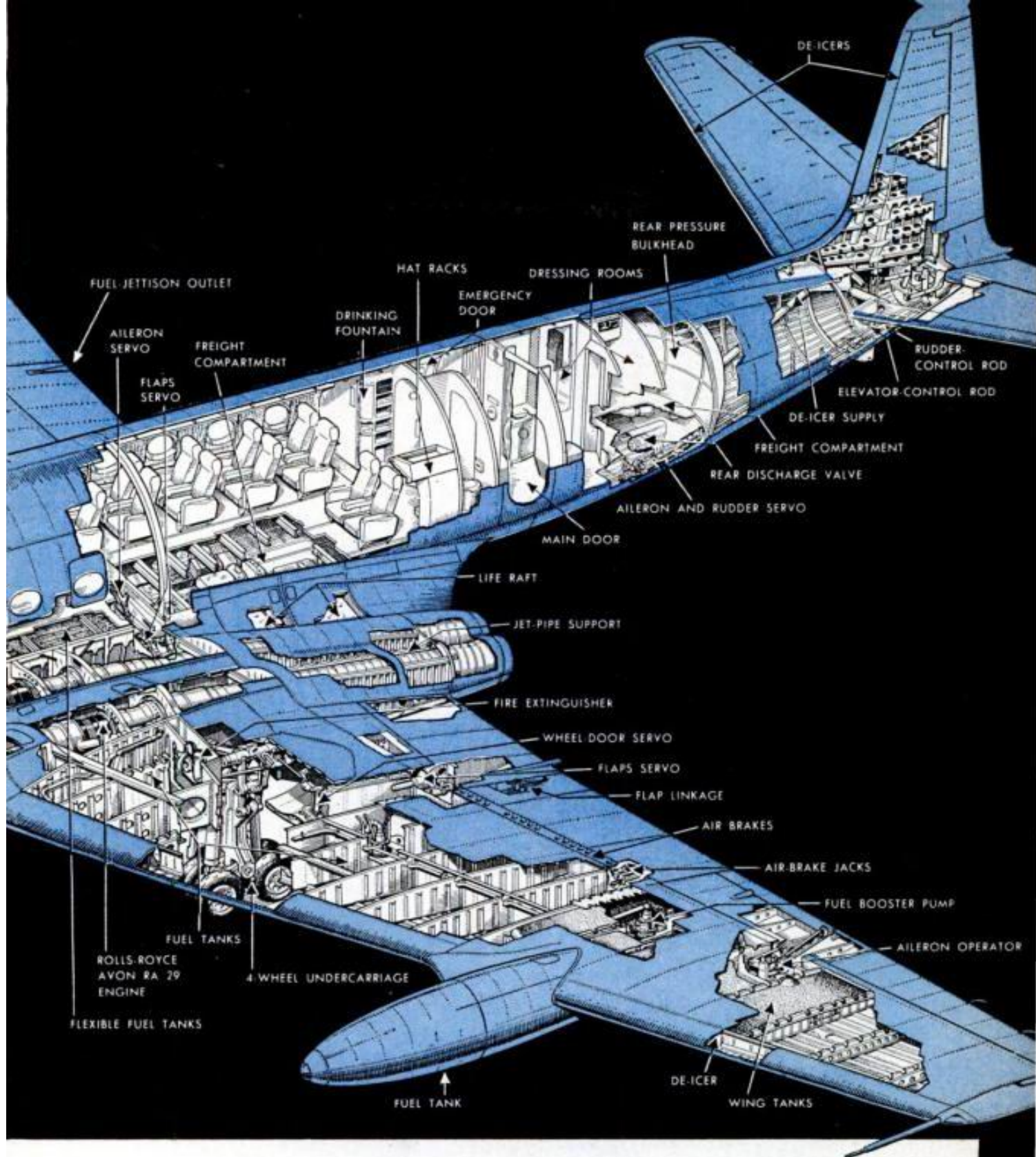


With this aircraft nowhere on earth will involve a journey of more than 36 hours.

NEW YORK to San Francisco in nearly an hour less than you could now fly from New York to Denver. Not in an Air Force plane, but in a commercial airliner seating 76 people.

That's what Britain's newest jet transport, the Comet Mark IV, is be-

ing designed to do. Its four Rolls-Royce Avon engines will whip it through high altitudes at 500-mile-an-hour cruising speeds. No fuel-gulpers, they will permit 3,000-mile nonstop flights: across the U.S., Vancouver to Honolulu, London to Dakar.

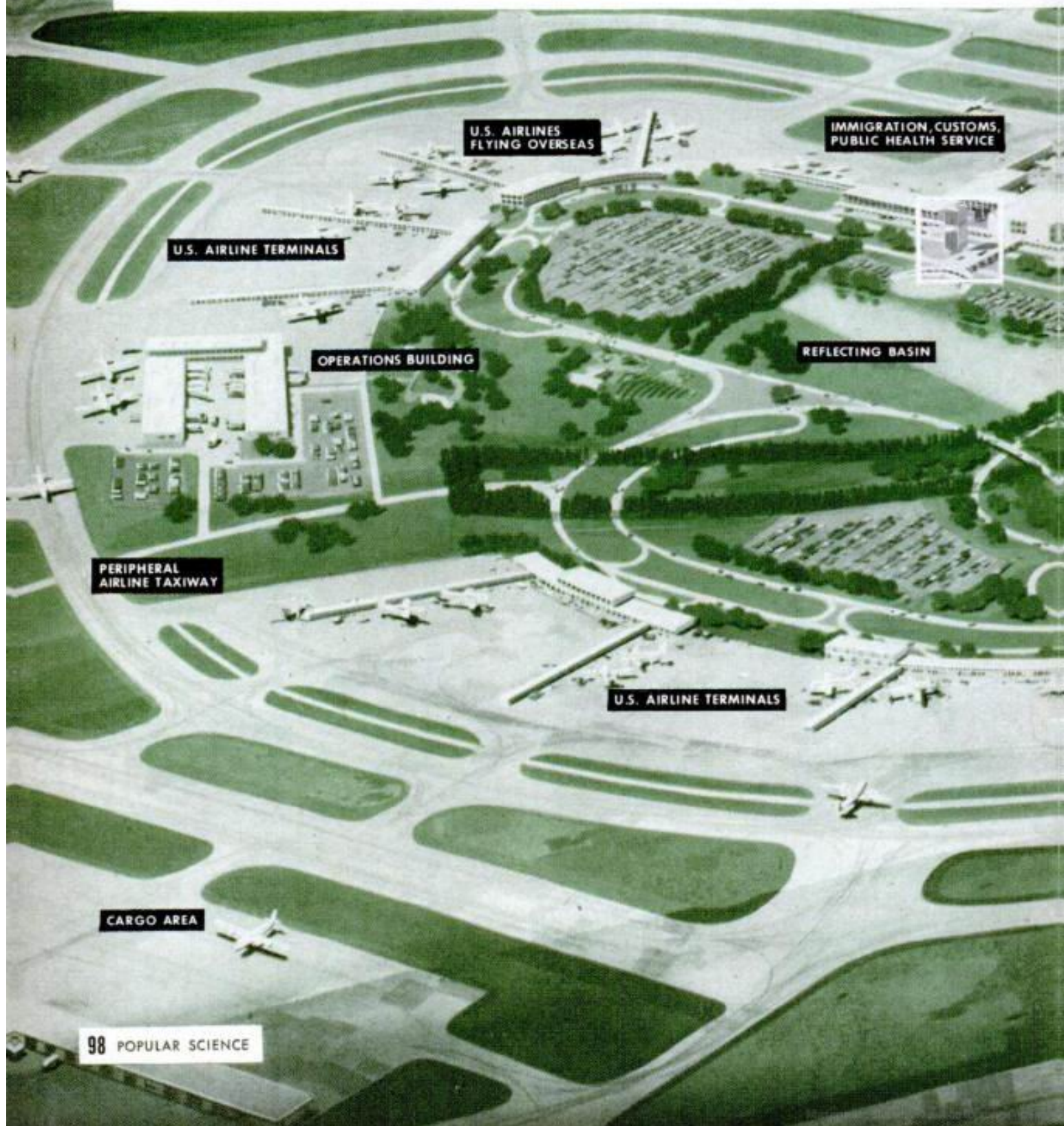


De Havilland's new Mark IV is a larger, improved version of earlier Comets that enjoyed brief popularity on Europe-Africa-Asia runs. Their jet engines made them fast, smooth and quiet. But a series of tragic crashes that were later traced to metal fatigue

grounded those original jet airliners.

Now British hopes for leadership in civilian aircraft are tied to the Mark IV. Its builders expect it to be flying passengers before U.S.-made jet airliners—the Boeing 707 and Douglas DC-8—get into service in 1958-59.

New Air Terminal Will Dwarf Them All

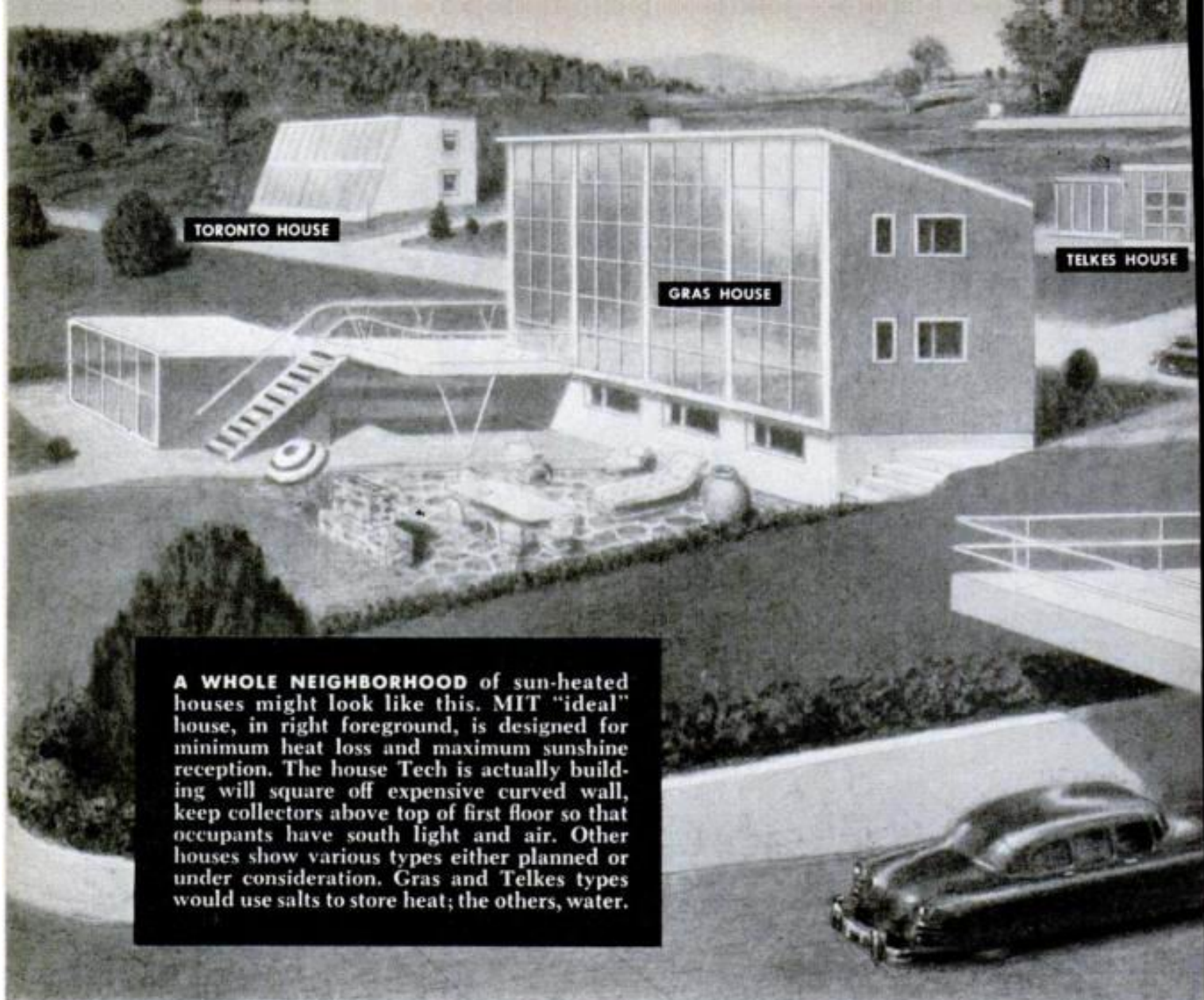


A \$60,000,000 Terminal City planned for New York International Airport is shown in this artist's drawing. When finished, it will be the world's largest passenger terminal.

The new 655-acre development, set in the 5,070-acre airport, is expected to serve 8,500,000 air travelers annually by 1965. Each of the major airlines will have

its own terminal building. Combined, they will be able to handle 140 four-engine airplanes at one time, compared with 29 now. Fifty acres of parking lots will accommodate 6,000 cars. Rising above the half-mile-long International Arrival Building will be the 11-story control tower shown in the sketch at left and also in the white box just below it.





A WHOLE NEIGHBORHOOD of sun-heated houses might look like this. MIT "ideal" house, in right foreground, is designed for minimum heat loss and maximum sunshine reception. The house Tech is actually building will square off expensive curved wall, keep collectors above top of first floor so that occupants have south light and air. Other houses show various types either planned or under consideration. Gras and Telkes types would use salts to store heat; the others, water.

New Sun Furnaces

Using the same unit year-round can cut equipment costs, make solar houses entirely practical.

By Hartley E. Howe

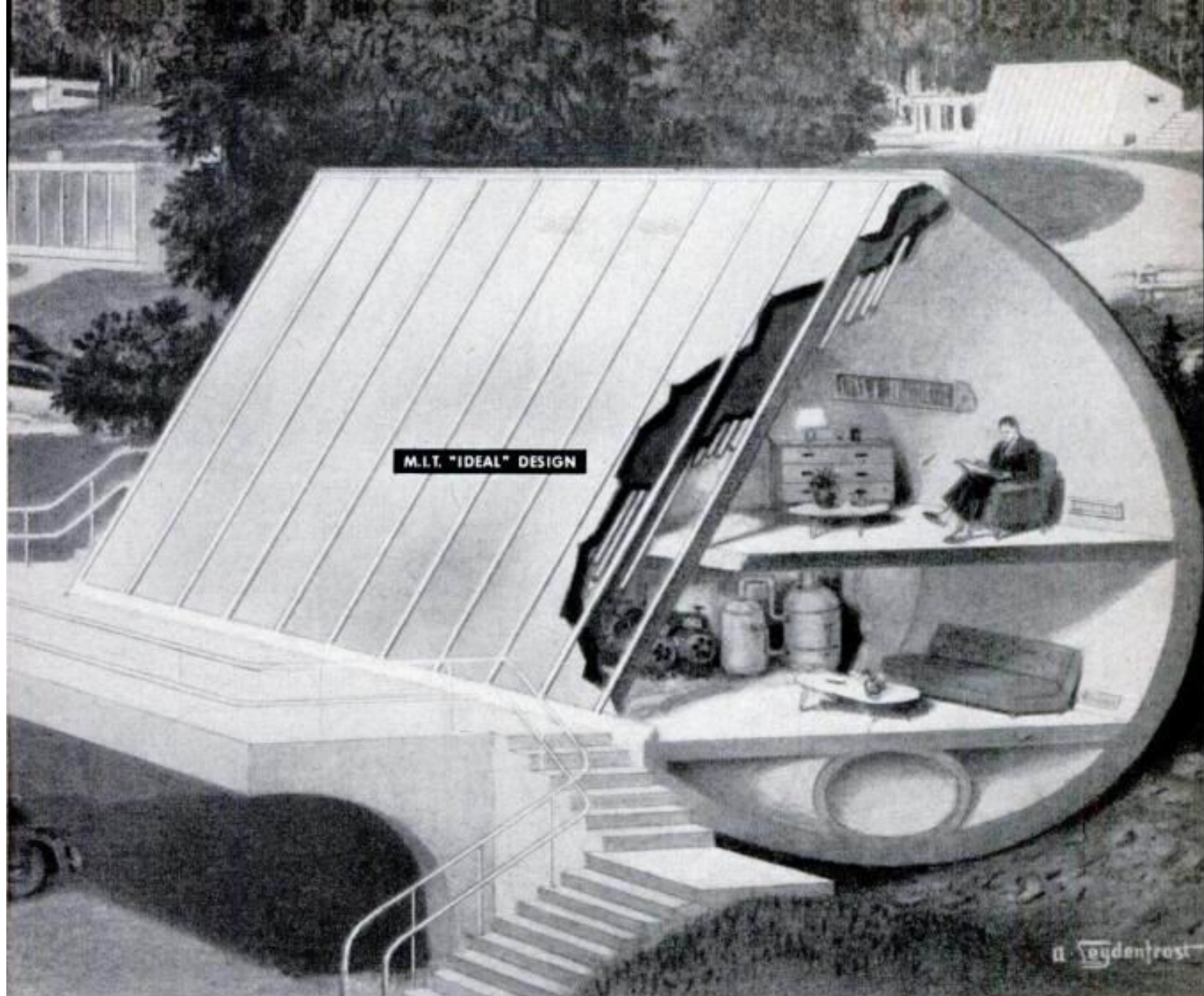
SOMEDAY you may live in a home that is cooled as well as heated by a sun furnace. Engineers are convinced now that sun power can be used in place of coal or oil to heat homes. But the equipment costs so much that it isn't cheap to use this free fuel. So they're planning to combine air-conditioning and solar-heating systems to cut the cost.

In some cases the same ducts and fans might serve heating and cooling. Reser-

voirs for sun warmth can hold "coolth" as well. One sun-heated house has already been cooled in summer by reversing the system to take heat out of the house.

Sun-cooling may hasten the switch to solar energy. That the switch is coming—fast—many experts believe. Dean George R. Harrison of Massachusetts Institute of Technology, for example, predicts many sun-heated homes will be built in the Southwest in the next five or 10 years. The Federal Government expects a market for 13,000,000 solar-heating plants by 1975.

Two solar-heated houses built near Boston in 1949—one designed by MIT



May Cool Houses, Too

experts and one by Dr. Maria Telkes of New York University—have demonstrated that sunshine *can* be successfully used for house heat as far north as New England. Now a whole new generation of sun-heated houses is planned. Four of these new houses are designed for cold northern areas.

A new MIT house should be ready for occupancy this fall. Like two earlier sun-houses designed by MIT, it will use a bank of double-paned glass collectors to heat water. But it will also have a standard oil burner.

The MIT experts are convinced that it is not economically feasible to heat a house entirely by solar energy as far

north as Boston. So they will provide the auxiliary oil furnace to add heat to the water from the storage tank when it cools off on cloudy days.

The new MIT house will be designed to provide all the conveniences and eye appeal of the best of today's houses that use conventional heat. It will probably be the average three-bedroom size.

It will be built by a commercial builder for occupancy by an average family, not scientists. While Tech's experts will study its operation for the first few years, it is expected to become eventually just another home—with an unusual heating system.

The Gras house is the first house



STRAPS LASH test pilot Johnston's feet to deck before he takes off in the flying platform.

"SURE I'd let my kids fly it," says Phil Johnston, first man to take the Navy's new flying pie pan aloft. "It's no trick at all. Anyone can take it up after a minute's instruction."

Once the round platform is up in the air, the pilot steers it by simply shifting his weight, leaning in the direction he wants to go.

The novel contraption uses an unusual principle of lift and propulsion—the

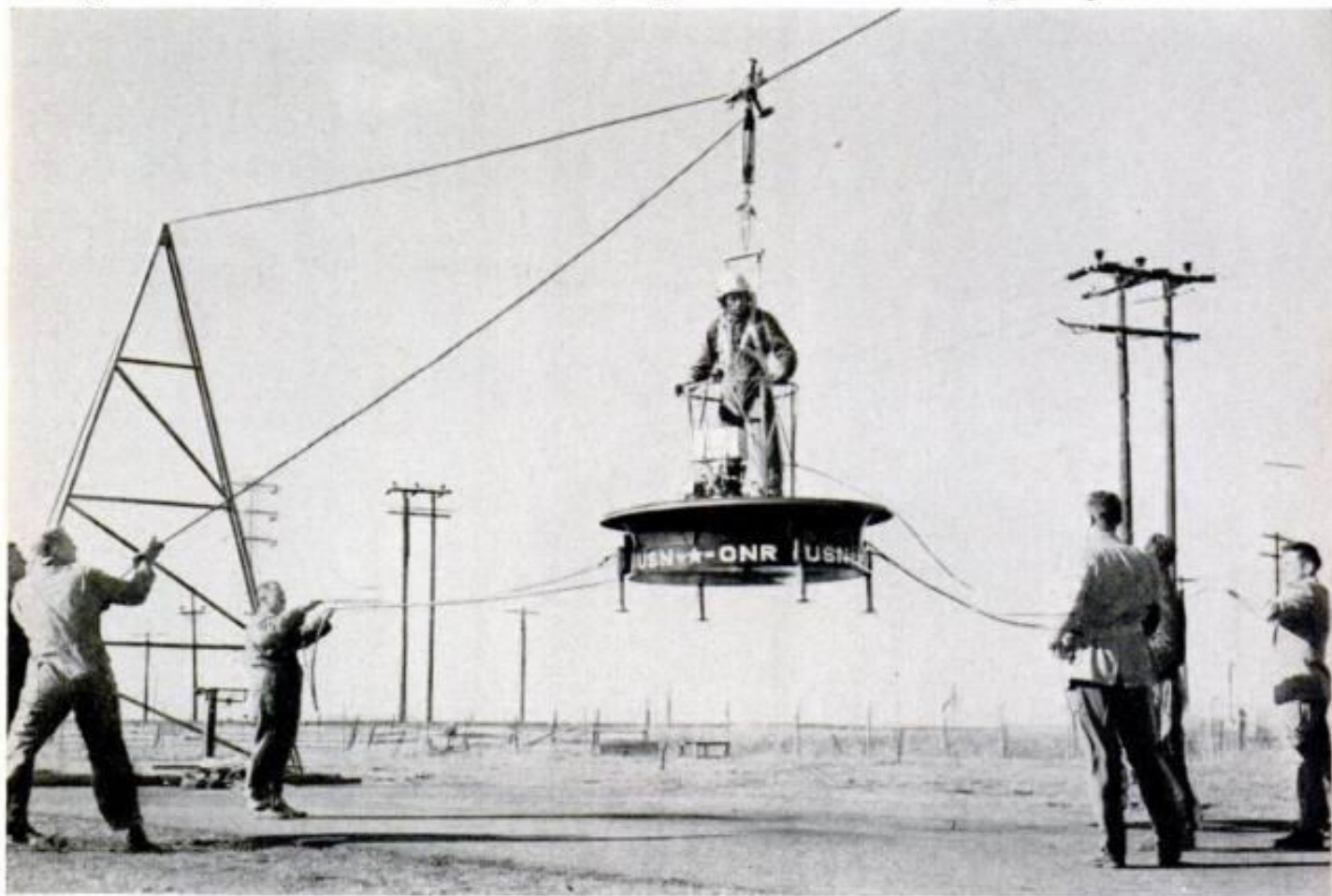
It takes one minute to learn to fly the

ducted fan. Two opposite-rotating fans, installed horizontally inside the platform, suck in air through holes, and then thrust it downward with great force, creating lift. Power is supplied by two engines developing 100 horsepower together.

The flying platform was developed and built by Hiller Helicopters, Palo Alto, Calif., as a research tool for the Office of Naval Research. The company's youthful president, Stanley Hiller, visualizes his vehicle as a military personnel carrier, with larger models carrying guns, tanks and supplies over tough terrain.

One problem to be solved is a means of emergency letdown. Right now, if either of the engines were to fail, the thing would fall like a brick. When that is overcome, pie-pan commuting from back yard to office may be a possibility.

During the test hops before free flight, the pie pan was harnessed to supporting cables.



Flying Pie Pan

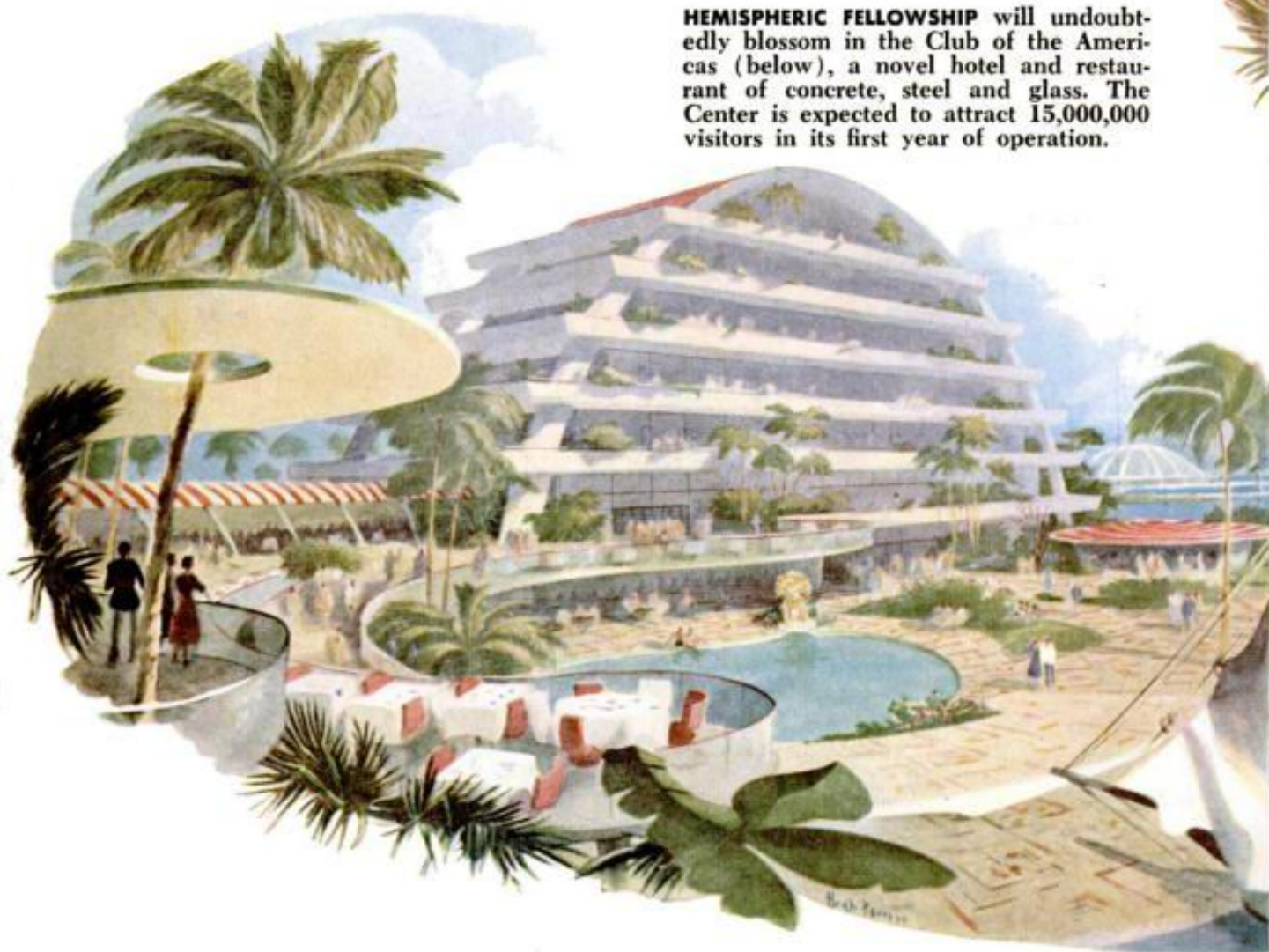




CIRCLING A LAGOON 10 miles north of Miami, the Center will aim to look like a vast subtropical garden. An amusement section, picnic and swimming facilities, horticultural and agricultural exhibits, a zoo and a playground for children are intended features.

Florida Plans New-World Fair

HEMISPHERIC FELLOWSHIP will undoubtedly blossom in the Club of the Americas (below), a novel hotel and restaurant of concrete, steel and glass. The Center is expected to attract 15,000,000 visitors in its first year of operation.



AN ENDLESS show, combining a trade fair with a fun fair and including top-grade cultural events as well, is expected to open beside a palm-fringed lagoon in North Miami, Fla., three years from now.

It will be a permanent world's fair that its sponsors hope will dwarf the

celebrated temporary world's fairs at Chicago and New York during the Thirties. Its name: Inter-American Cultural and Trade Center.

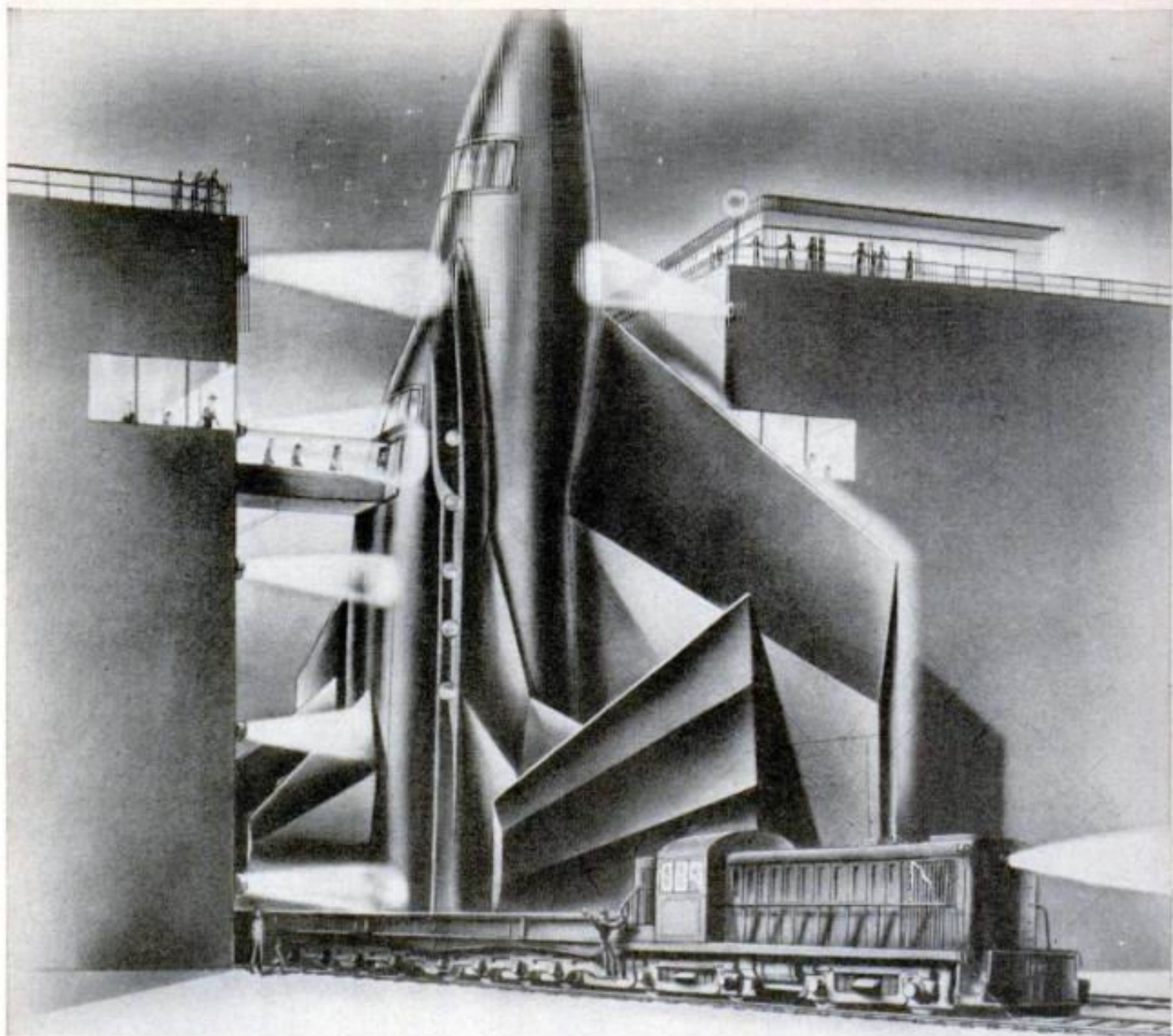
Planned to provide an enduring and beautiful showcase for exhibits from all the nations of North and South America, the Center will cover 1,800 acres.



MONORAILWAY of aluminum and glass, barely visible under a row of palm-tree tops at left center in the drawing above, will carry sightseers for an elevated tour of the Center's grounds. Electronically controlled, air-conditioned boats are planned to cruise the lagoon and the Center's canals.

MANY-PURPOSE AMPHITHEATER of advanced design will be the theme center of the permanent fair, scheduled to open on Jan. 1, 1958. Restaurants will feature native dishes of the Americas. Entertainments will include ballets, rodeos, dramas, concerts, art shows, sports contests.





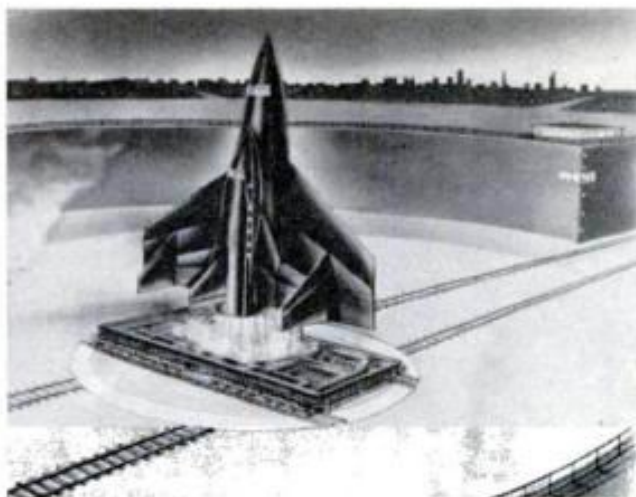
1 BOOSTER UNIT and its piggyback passenger ship would stand in nose-up, rocket take-off position during loading. A train would tow the 300-ton combo to the launching site.

Rocket Liner Would Skirt Space to Speed Air Travel

DESTINATION Earth is a new twist in passenger-carrying spaceships. Spanning the U.S. or the Atlantic would take an hour and a quarter, the Pacific an hour and a half. A piggyback ride on a booster rocket would start this super-liner of tomorrow on a fantastic flight to an altitude of 200,000 feet and a brief

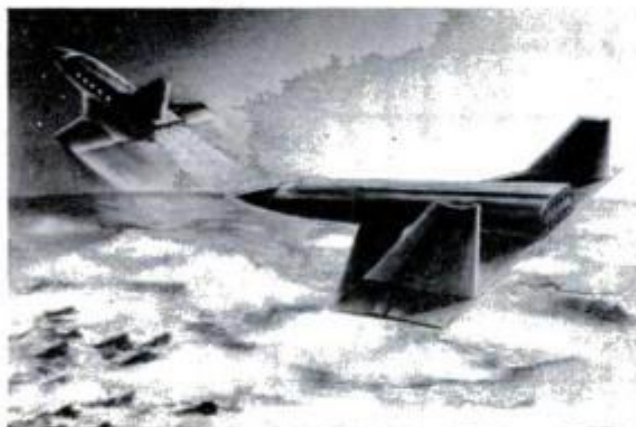
top speed of 17,500 miles an hour, 24 times the speed of sound.

How this high-speed, globe-girdling air travel would be accomplished is shown in these drawings. They are based on design proposals of a Bell Aircraft Corp. scientist, Dr. Walter R. Dornberger, who worked on German V-2 rockets.



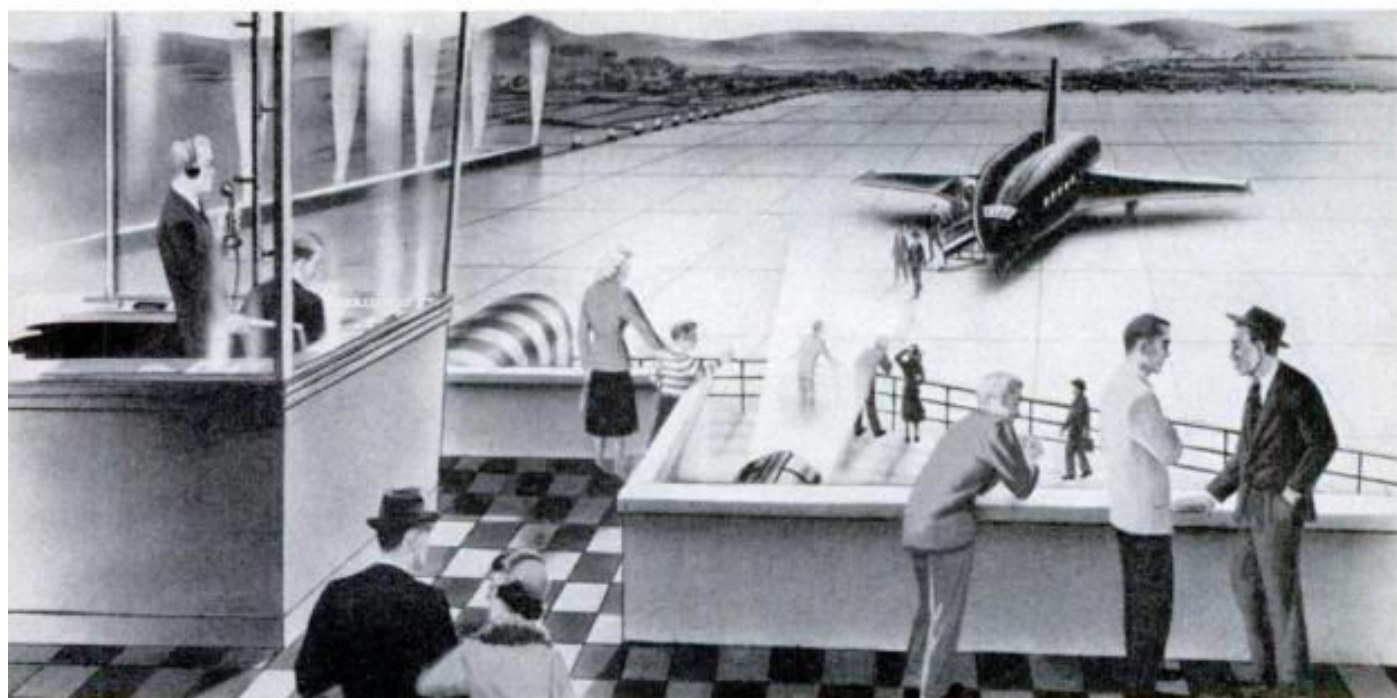
2 LAUNCHING would be from the center of a heat-resistant pit, with eight rocket motors blasting off with a thrust of 760,000 pounds. Both booster and plane units are crew-manned.

4 TWO MINUTES LATER, at an altitude of 70,000 feet, the passenger rocket would blast itself free from the booster, as the latter cut its rockets and glided back to base.



3 DURING TAKE-OFF, passenger seats would be one above the other on each side of an aisle. They would rotate on a horizontal axis when the ship leveled off in flight.

5 PASSENGER PLANE'S ROCKETS would blast it spaceward for about two minutes, then be cut. Silently it would continue to climb, then lose speed and glide back to earth.



6 SUPERSONIC SPACE-BRUSHING FLIGHT would end in a gentle glide through the lower at-

mosphere, landing on a runway in the manner of a conventional airplane.



CLOSE FRAMING of the hull is shown in this view of the *Glacier* under construction.

hard, glistening icy ones, tinted with varying shades of blue and green.

They would drift north with the current, then head across Baffin Bay to the Canadian side and head south. Some of them will arrive in the North Atlantic this summer, some not until next year, melting and rotten midgets, but still a mortal threat to thin-hulled ships.

"You'd think," said Mr. Fry, "that those towering icebergs would be swept swiftly

along with the wind, which would have little effect on low ice floes. But just the opposite is true. Flat ice is at the whim of the winds. The icebergs, on the other hand, because so much of them is under water, are impervious to the wind. It is the slow, often tortuous, currents that carry them along to their final destination and disintegration."

This time, when I brought out my camera, Mr. Fry raised no objections. He had his own camera in action.

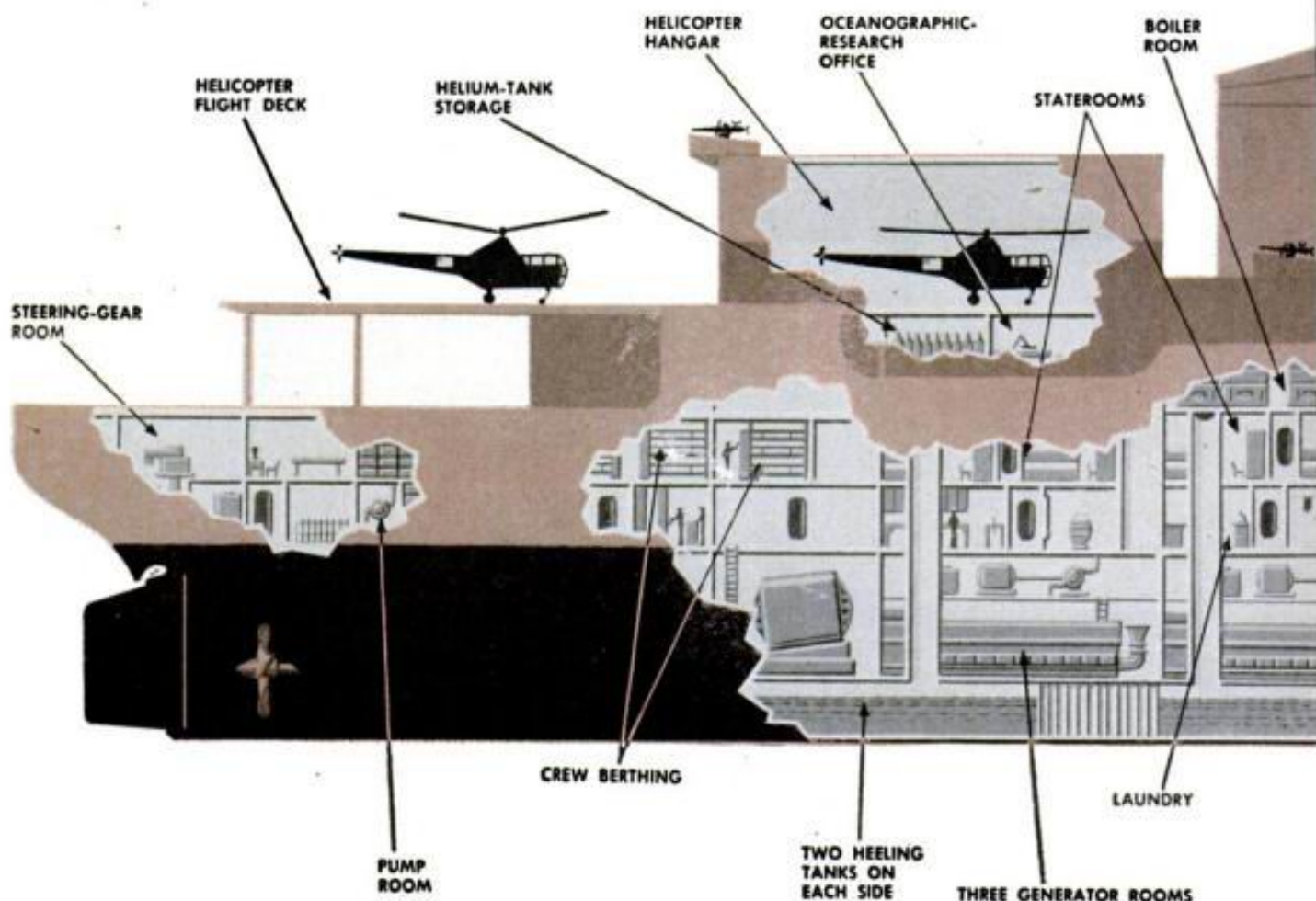
Ice Pack Wears a Halo

"Have you noticed the ice blink?" he asked, after we had been climbing all over the *Atka* on our snapshot safari. I looked at him, puzzled.

"Ah, I'm sorry," he apologized. "I forgot that the Arctic is new to you." He pointed to the northeast. "See that bright halo of light out there?"

I looked, and did see a brightness.

"That's caused by the reflection of light on ice. It's called the ice blink. When an ice sailor sees it, he knows that he is



headed for an ice pack. We should be there in a couple of hours."

In retrospect, the ice we saw that day was not impressive. It was slush and puddle ice. A few days later I left the *Atka* to board the U.S. Coast Guard's *Eastwind*, which was scheduled to proceed to the northernmost land weather station in the world, a tiny cluster of shacks known as Alert. Once a year an icebreaker tries to reach Alert with supplies and personnel replacements.

On Wednesday morning, August 4, the *Eastwind*'s loudspeakers bellowed that Capt. George H. Bowerman wanted to see Mr. Johansen on the bridge.

Capt. Bowerman was dressed in his parka, the fur-lined hood down. "Well," he said, "you wanted to see some ice-breaking. You're going to get your wish. That's polar ice ahead of us."

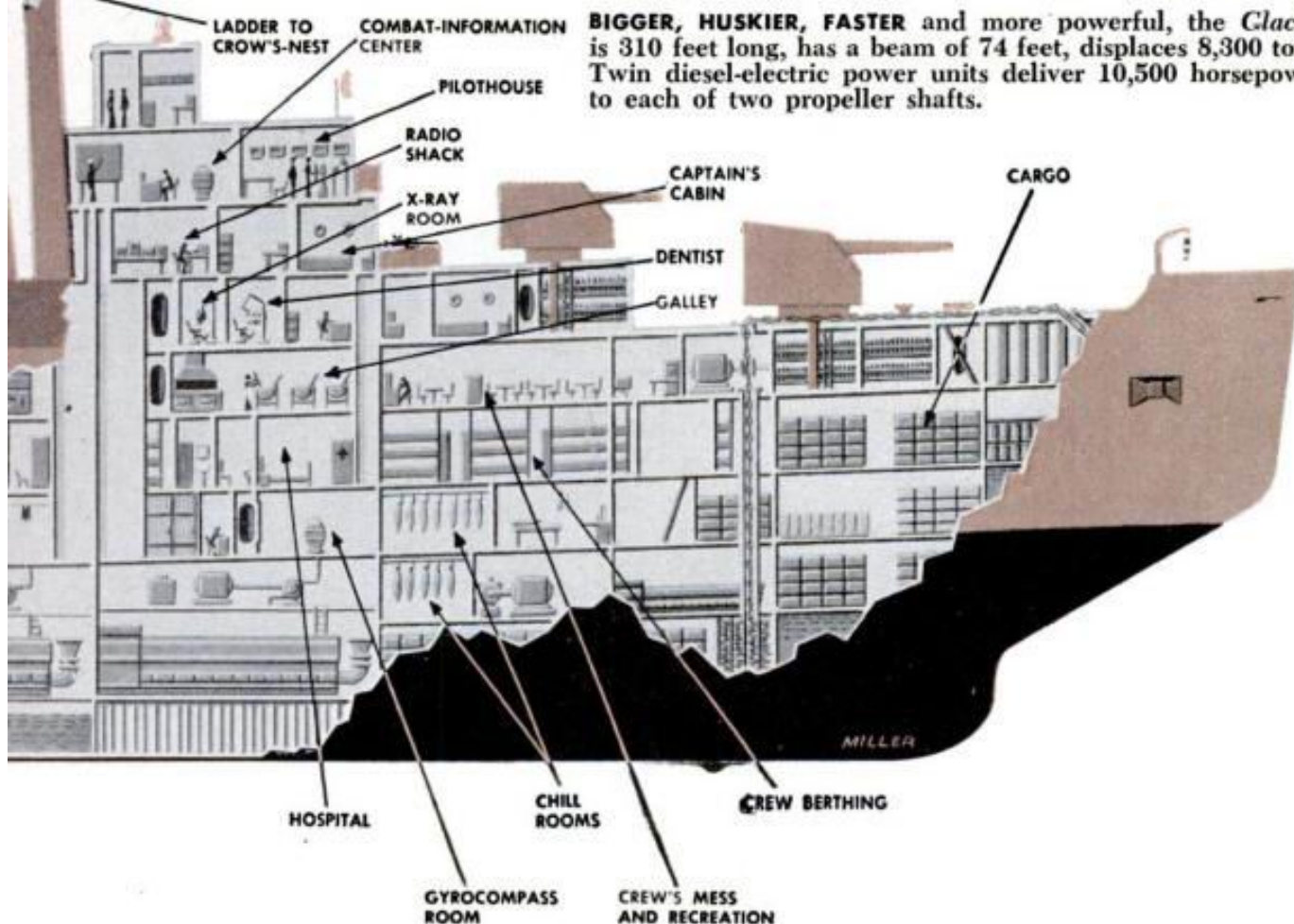
We were in Smith Sound, a little above latitude 78 degrees north, between the east coast of Ellesmere Island and the west coast of Greenland. From the fo'c'sle I already had seen the vast ex-



A NEW U.S. NAVY ICEBREAKER takes form. The *Glacier* was launched last August.

pense of pack ice toward which we were heading. It was awe-inspiring—white, with high irregular ridges, steely blue ice shining through where the snow cover had melted, cold, forbidding, lifeless—like the tortured surface of some science-fiction planet.

[Continued on page 264]



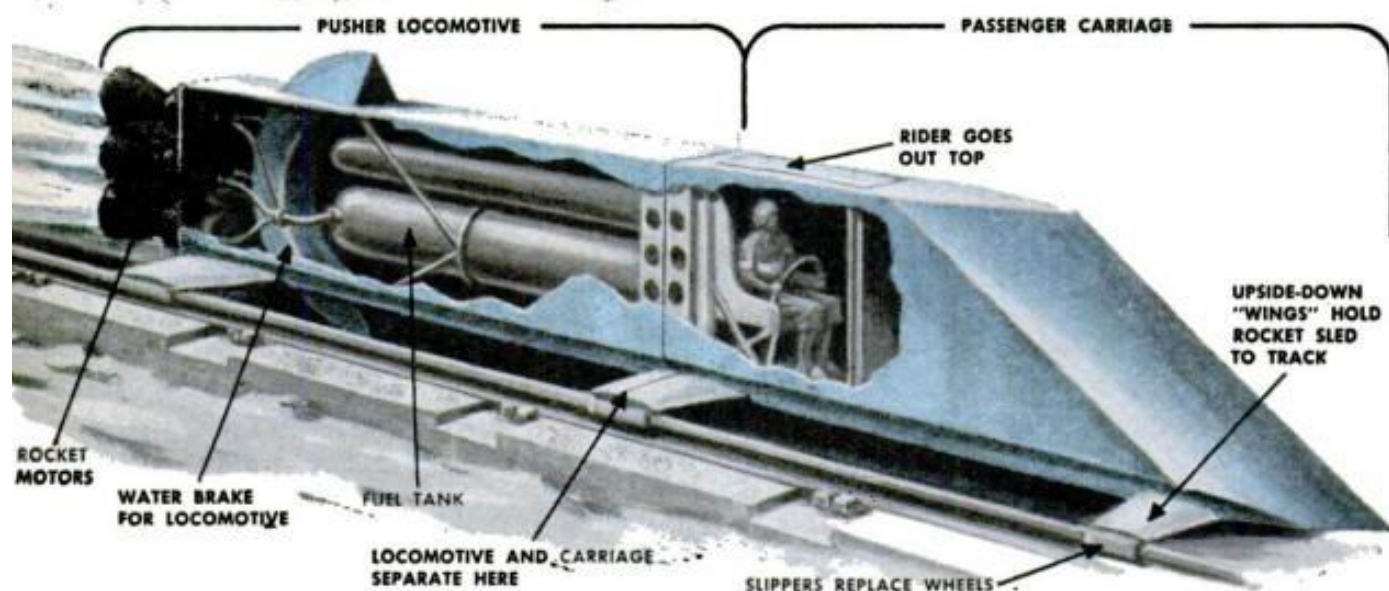
BIGGER, HUSKIER, FASTER and more powerful, the *Glacier* is 310 feet long, has a beam of 74 feet, displaces 8,300 tons. Twin diesel-electric power units deliver 10,500 horsepower to each of two propeller shafts.

Please turn the page for Mr. Fry's adventures

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Rocket Car to Hurl Man

First dummies, then human beings, will take a nightmare ride to find how to bail out of tomorrow's supersonic warplanes.



CONTROL-HOUSE OPERATOR (below), at periscope window, stands ready to throw lever that fires rockets, starting sled and rider on way. On roof are warning lights, siren, loudspeaker.

AT LAUNCHING PAD, start of 10,000-foot-rail straightaway to cliff's edge, two-section rocket sled is towed from underground fueling pit and maneuvered into position to make its run.



1 EJECTED PASSENGER AND
SPEEDING CARRIAGE
HURTLE OVER PRECIPICE

2 PASSENGER'S CHUTE
OPENS FOR DESCENT
TO CANYON FLOOR

LOCOMOTIVE
BRAKING

CARRIAGE
COASTING

Over Cliff

YOU sit in a car powered by roaring rockets. As it hits full speed, an explosive charge hurls you out. And you find yourself sailing through the air over a 1,500-foot precipice.

That nightmare is just what will happen in a \$2,000,000 research project to develop ejection gear with which airmen can bail out safely from future supersonic U. S. warplanes.

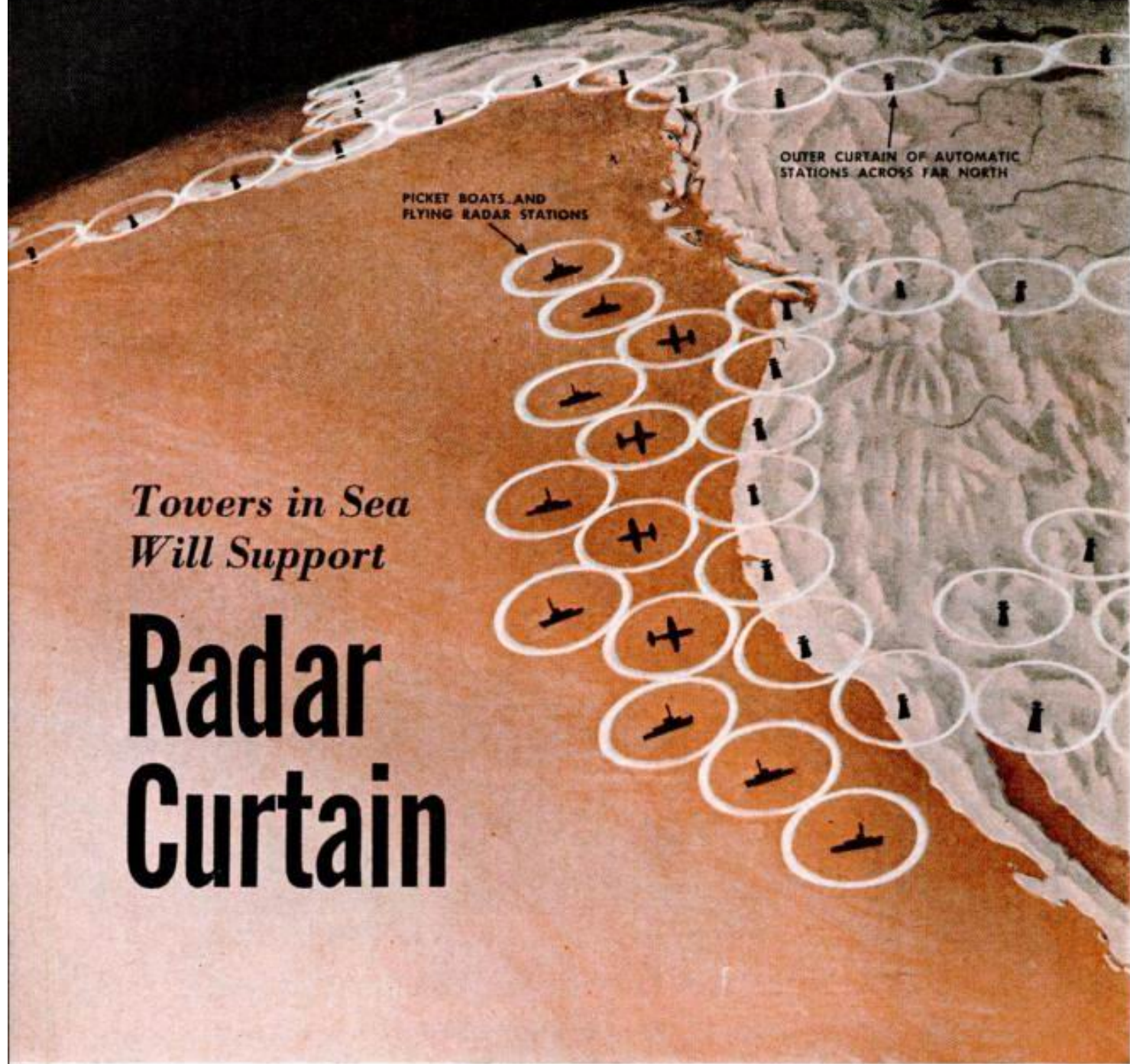
Next year a rocket rail sled will begin runs on a two-mile straightaway to the edge of a Utah mountain flat. First it will pitch off dummies, then humans, to descend on chutes. Over the cliff goes the passenger carriage, too, its fall being checked by a chute of its own.—Andrew R. Boone.

TRACK ENDS in space. Locomotive stops—but the separable carriage races on, so as to reach ejection point at full speed, and then hurtles over cliff. Cameras in towers film the tests.



DECEMBER 1954 85

3 LARGE CHUTE
CHECKS FALL OF
CARRIAGE TO
PERMIT RECOVERY



*Towers in Sea
Will Support*

Radar Curtain

A MODERN version of the Great Wall of China is being built by the United States against air attack. The wall is invisible. It consists of radar signals, probing for unidentified aircraft.

Newest addition to the wall will be a radar curtain projected from a series of artificial islands off the Atlantic coast from Virginia to Newfoundland, as much as 125 miles from shore.

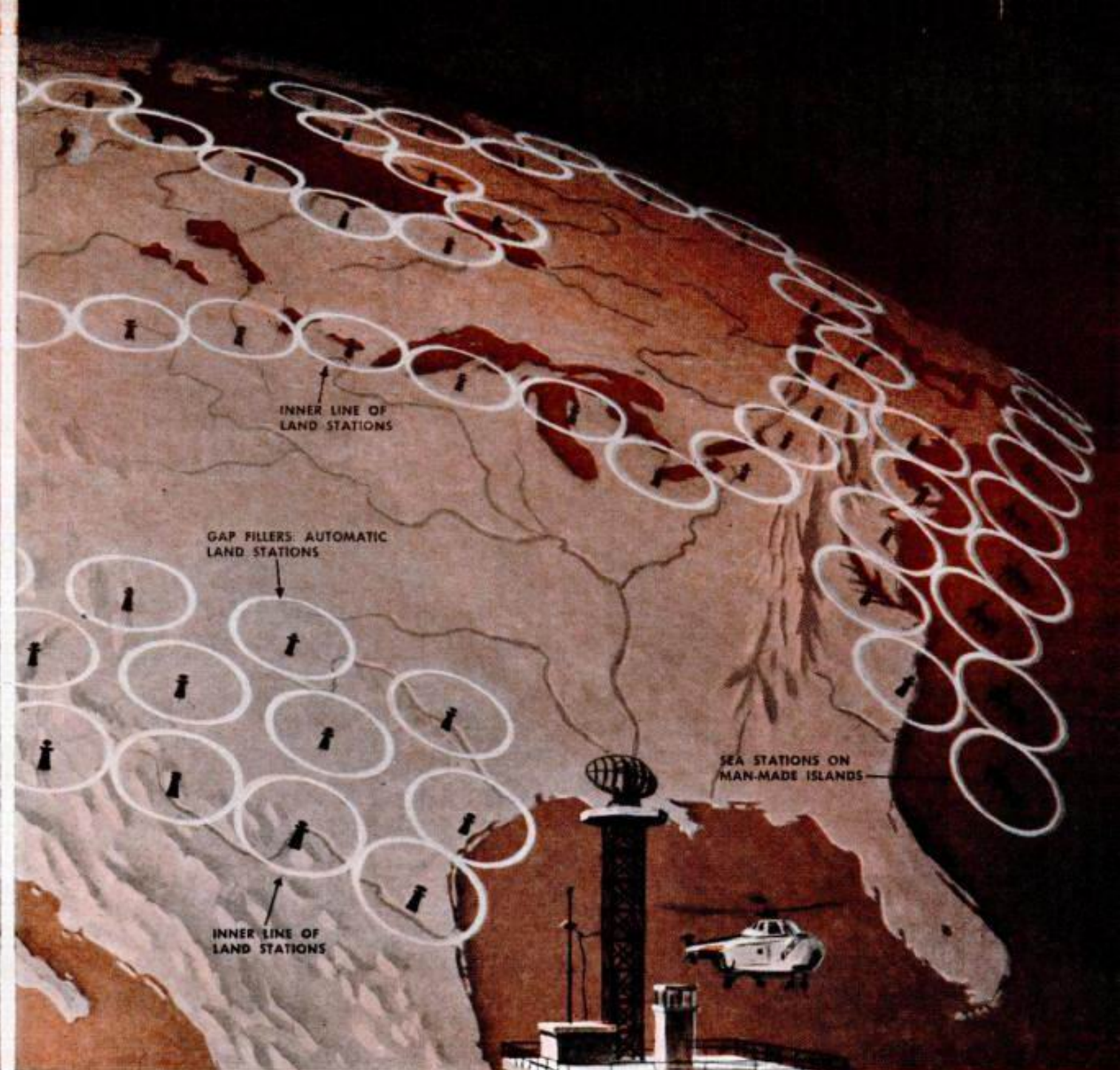
Construction of such a chain of radar stations is possible only because the wide continental shelf off the Atlantic coast provides shallow water.

At the same time, gaps in the existing

radar-defense wall will be filled with 485 new radar-warning installations across the top of the nation.

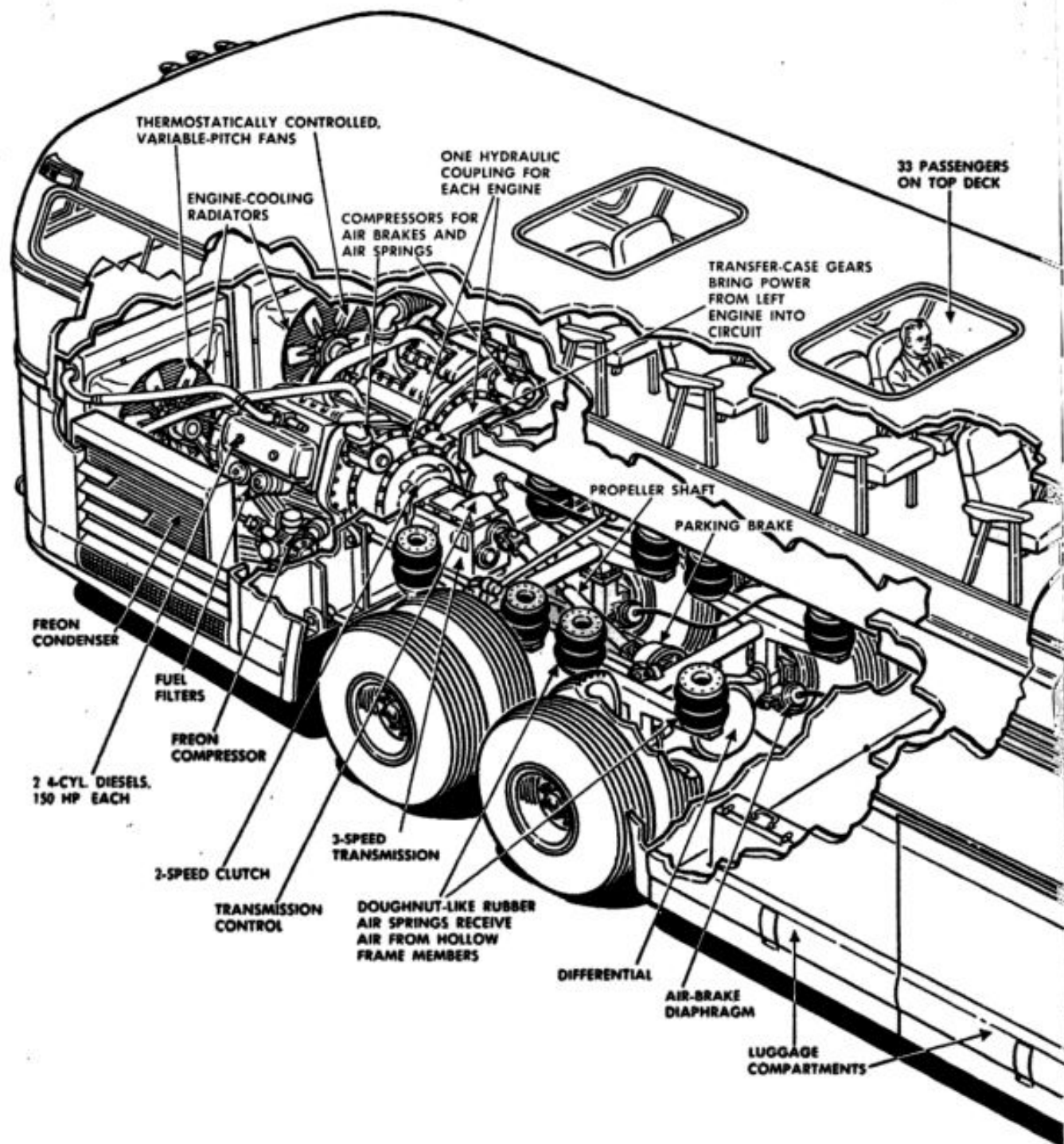
Off the Pacific coast, where there is no continental shelf to build artificial islands on, Navy picket boats and long-range, radar-toting airplanes throw up a wall to warn of hostile aircraft.

Picket boats and planes also patrol the Atlantic coast south to Florida, beyond the projected island stations. And early-warning networks link our Caribbean bases and stretch across the Arctic hundreds of miles north of our northern borders.



MAN-MADE ISLAND for chain of radar stations off Atlantic coast is patterned on platforms used by oil drillers in Gulf of Mexico. Built on land, islands will be towed to sites at sea. There six-foot caissons will be dropped to ocean floor through holes in platform, and air jacks on caissons will lift platform above water. A tower will contain radar, radio and weather stations. The islands will generate their own electricity and provide quarters—including recreation facilities—for 20 to 30 men. Bright spot: Crews will be rotated monthly.



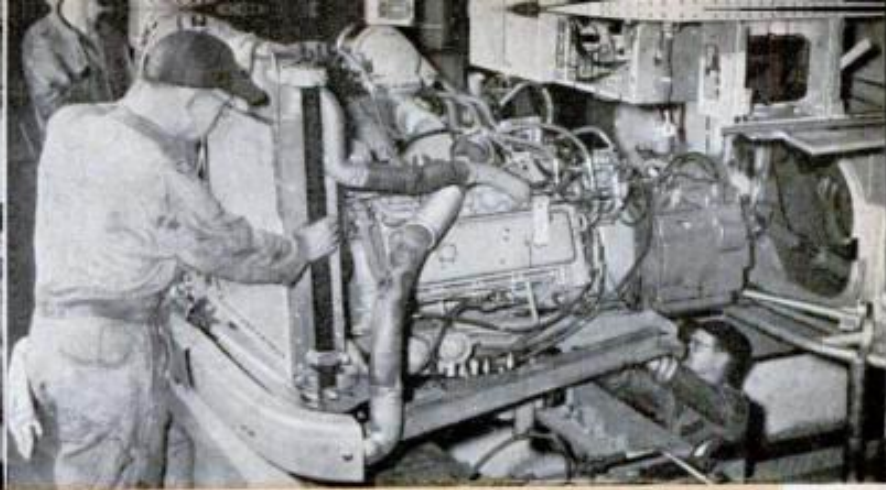
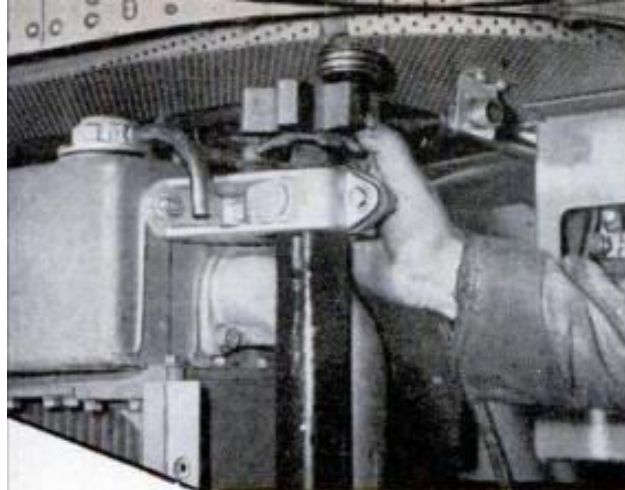


riers. This writer, taking a two-hour junket with GMC's chief inspector in the first bus off the line, found it outrageously comfortable. The only drawback, in fact, is the tendency to make you duck when the upper windshield whooshes through foliage on back roads. Company officials gravely explain that tree-nuzzling is no problem on main roads.

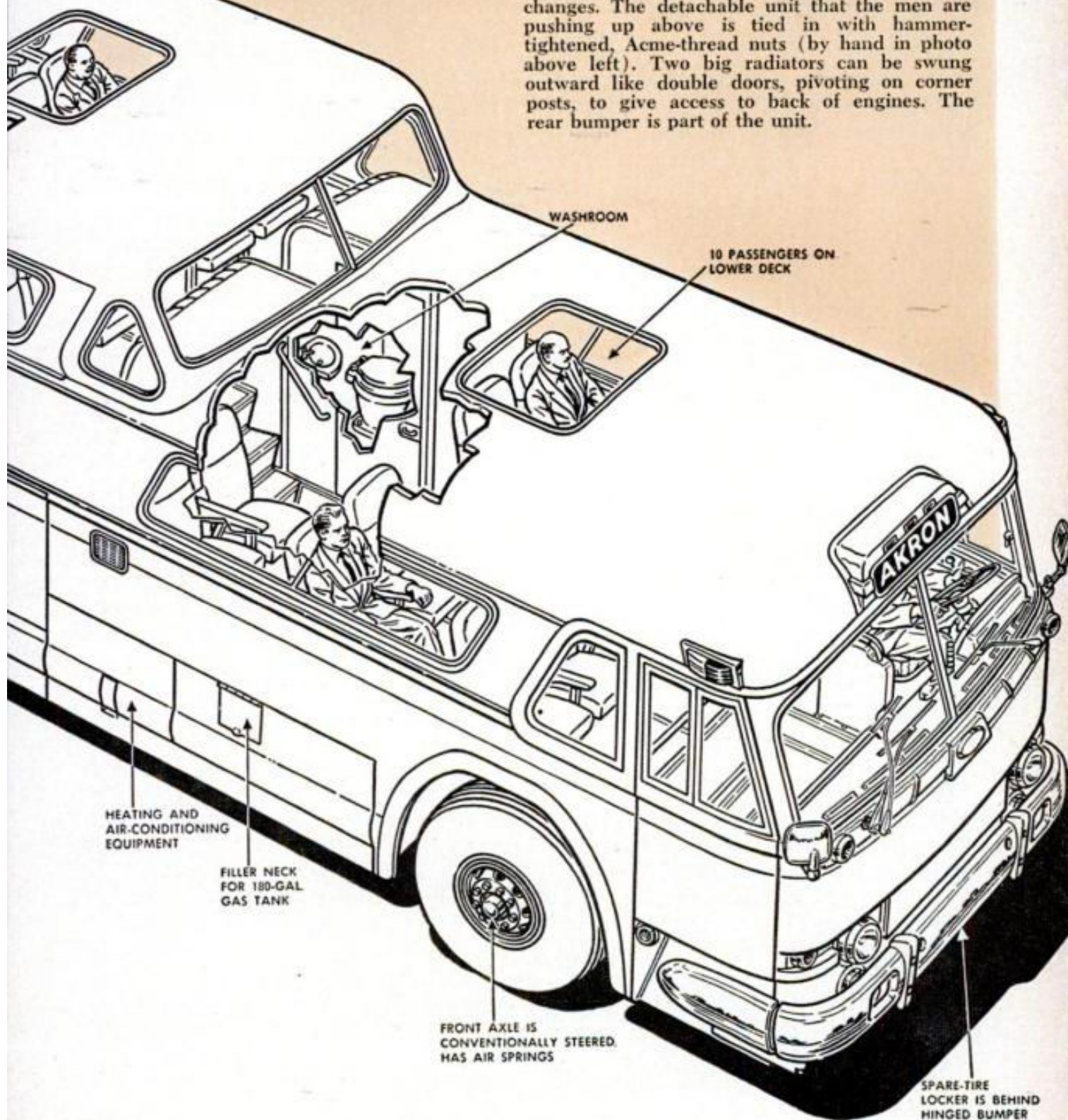
Big baby. The Scenicruiser is built out close to national maximums. She's 40 feet long, and just a fraction of an inch shy of being 11 feet high and eight feet wide. (Those fractions are deliberate:

They're insurance against the chance that manufacturing variations might meet up with a persnickety highway inspector.) She tips the beam at 30,000 pounds when roadworthy but unloaded, and willingly totes a five-ton payload. This can be 43 passengers and their baggage, plus 1,500 pounds of mail and express.

The driver and 10 passengers share the lower deck, which has a tinted skylight, big windows and the washroom. Up three steps is the top deck—on both levels the seats are one step above the aisle—with places for 33 customers in



PLUG-IN POWER PLANT permits speedy engine changes. The detachable unit that the men are pushing up above is tied in with hammer-tightened, Acme-thread nuts (by hand in photo above left). Two big radiators can be swung outward like double doors, pivoting on corner posts, to give access to back of engines. The rear bumper is part of the unit.



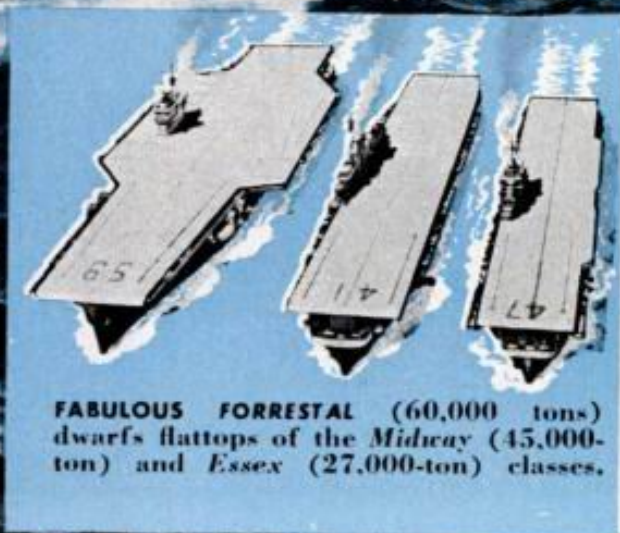
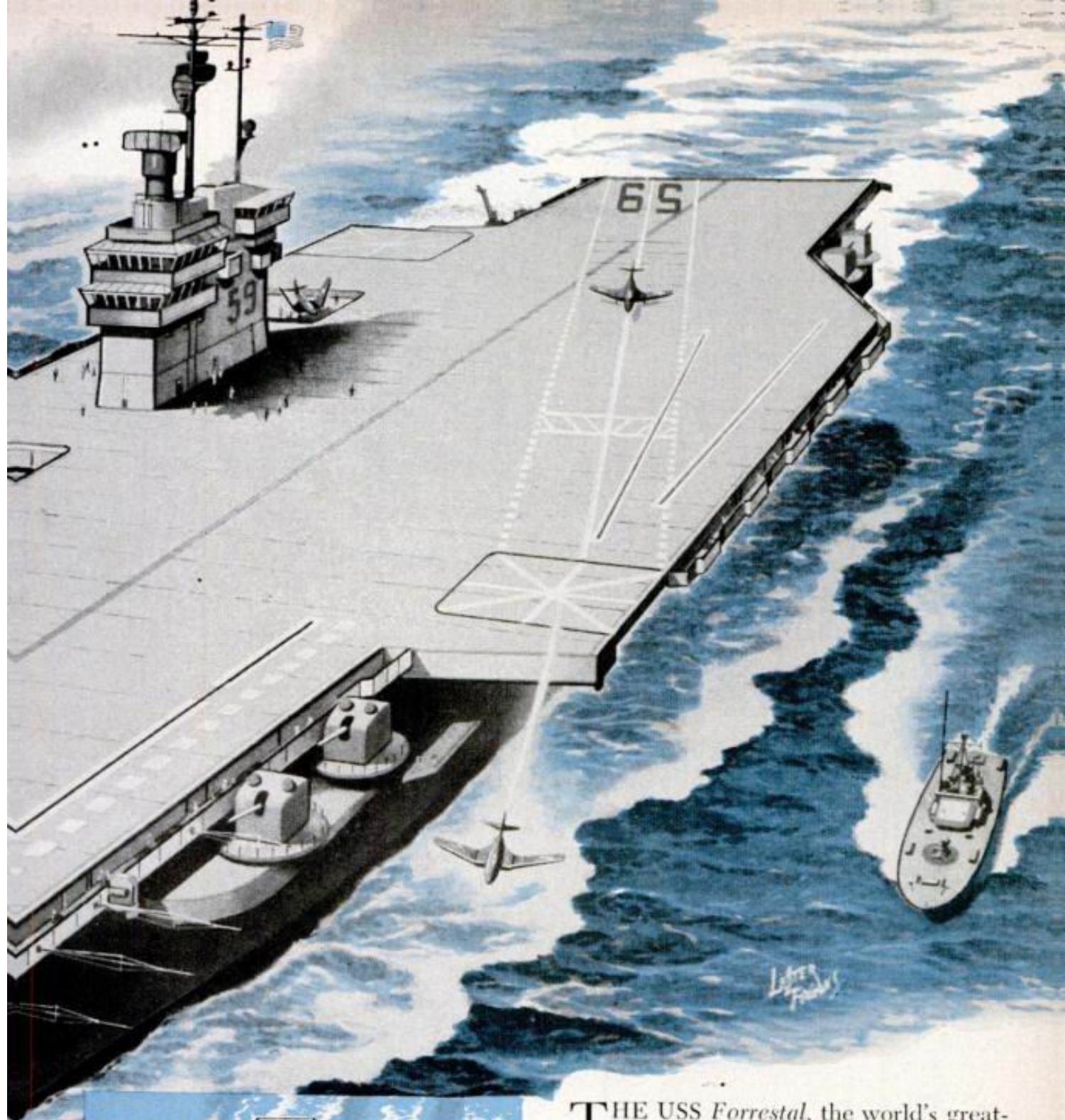
The U.S. will soon launch the

Biggest Ship Ever Built

Under a steel-plate flight deck five city blocks long, the giant aircraft carrier Forresteral packs a \$217,000,000 punch.

By Henry B. Comstock





FABULOUS FORRESTAL (60,000 tons) dwarfs flattops of the *Midway* (45,000-ton) and *Essex* (27,000-ton) classes.

THE USS *Forrestal*, the world's greatest single investment in seaborne striking power, will be backed out of a graving dock into the James River at Newport News, Va., this fall.

Sixteen thousand engineers, draftsmen and builders have worked on her, and \$217,000,000 has been invested in her.

Now the great ship fans out over her dock like an A-bomb's mushroom molded in steel. She has the same impersonal killer-look—a bare-stage ugliness that gives your imagination plenty of runway. More than a city block wide



Four-pointed, X-shaped tail is landing gear of Lockheed XFV-1, shown in take-off position.

New U.S. Planes Leap Straight Up

Standing on their tails, these "vertiplane" fighters will take off like rockets.

TWO new Navy fighter planes designed to take off straight up and land tail down would make almost any ship an aircraft carrier. Poised nose-up on the ground, the 500-m.p.h. experimental Lockheed XFV-1 and Convair

LOCKHEED XFV-1



PILOT climbs a portable ladder (left) to reach cockpit of the Lockheed XFV-1 vertical-take-off, swept-wing fighter. The special mobile platform above permits the plane to be tilted for easier maintenance.

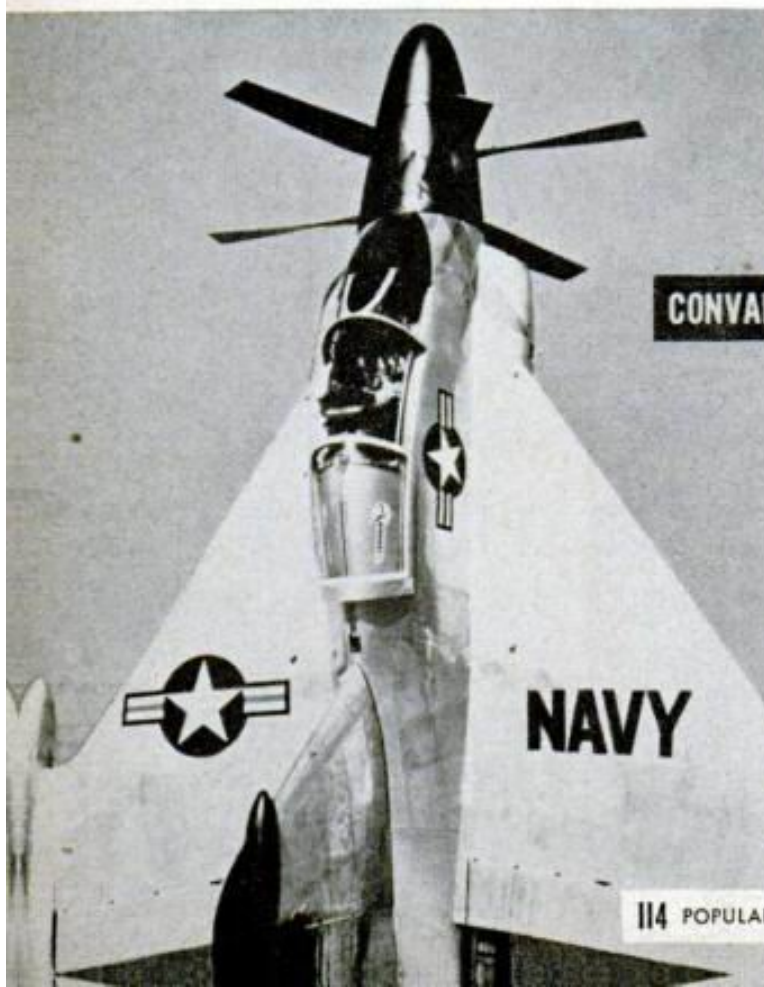
XFV-1 look like spaceships from science fiction.

Power to lift the planes straight up into the sky comes from twin turbojet engines, reported to be of 5,500 horsepower, driving a pair of specially designed, high-speed contra-rotating propellers. Once in the air, the pilot levels off into conventional flight position. For landing, he maneuvers back into the

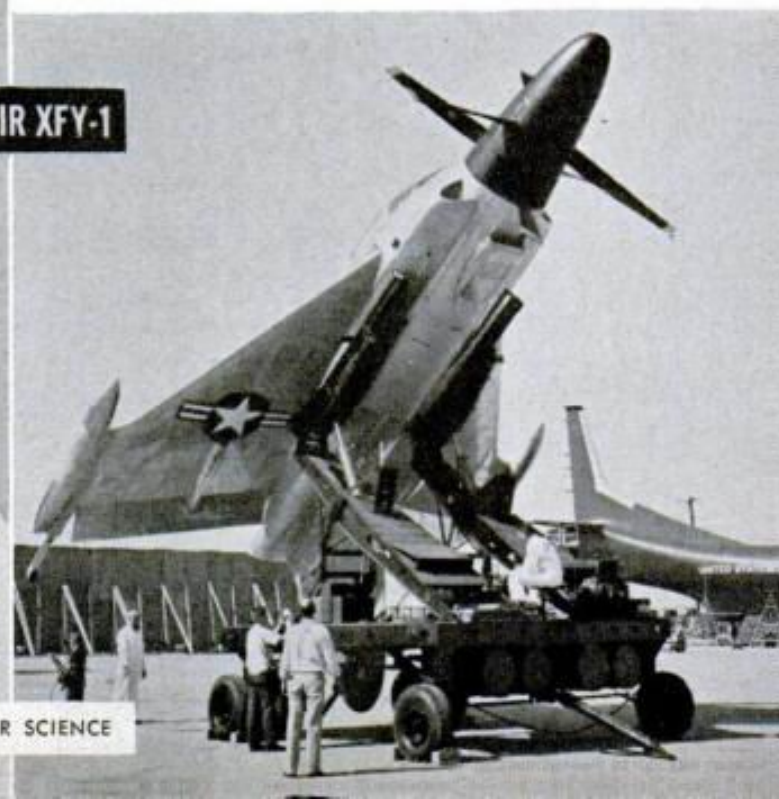
perpendicular and backs down, hovering in mid-air like a helicopter if necessary. A rotating seat automatically pivots the pilot into the proper position for any attitude into which he puts his plane.

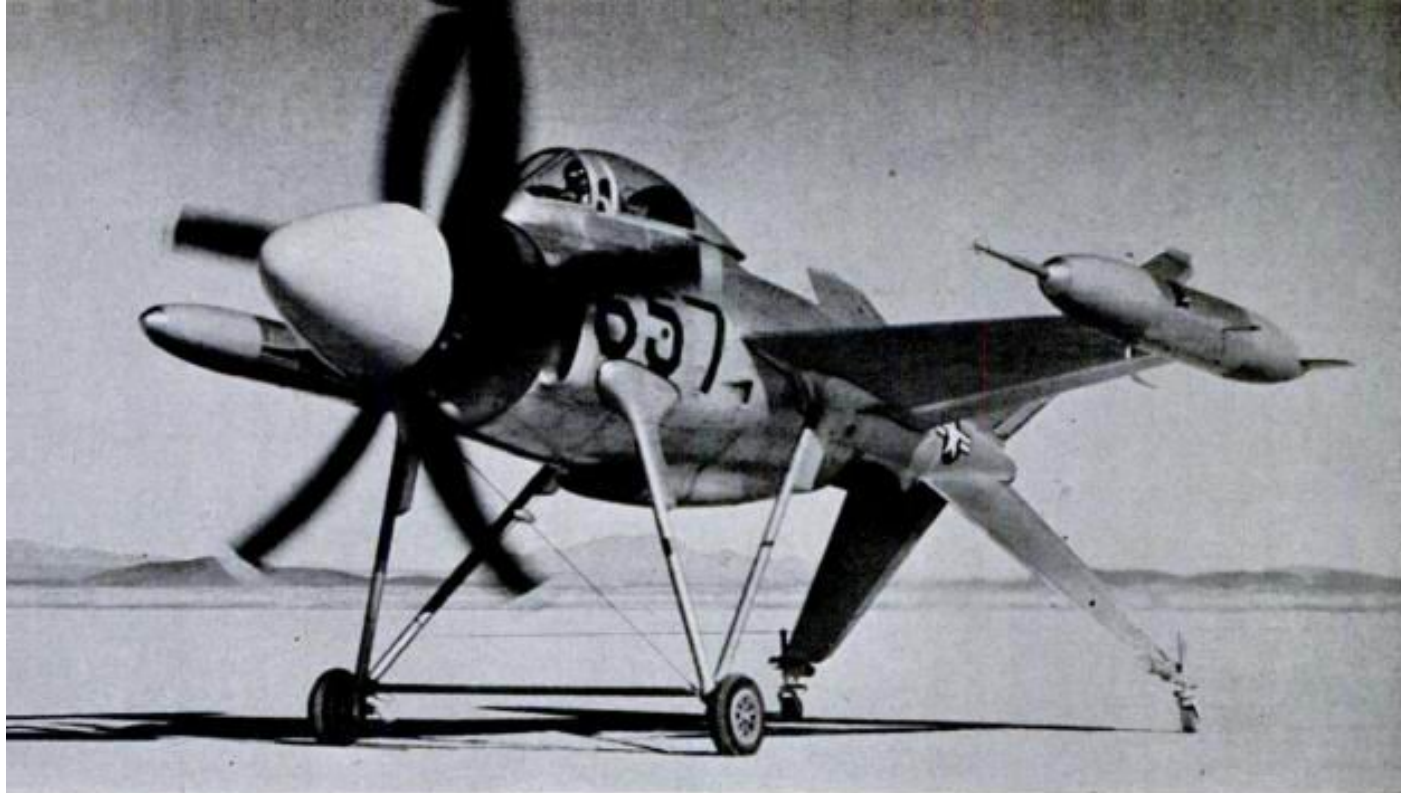
The planes were not designed for use aboard carriers, but for various ship-to-shore missions (termed "secret" by the Navy) where neither flight decks nor land runways are available.

CONVAIR XFY-1 is a delta-wing fighter. It is shown at left in the position in which it takes off and lands. The mobile vehicle below is used to transport the plane on the ground, and to raise and lower it.



CONVAIR XFY-1





The XFV-1 has auxiliary landing gear also, used for normal take-off during test flights.

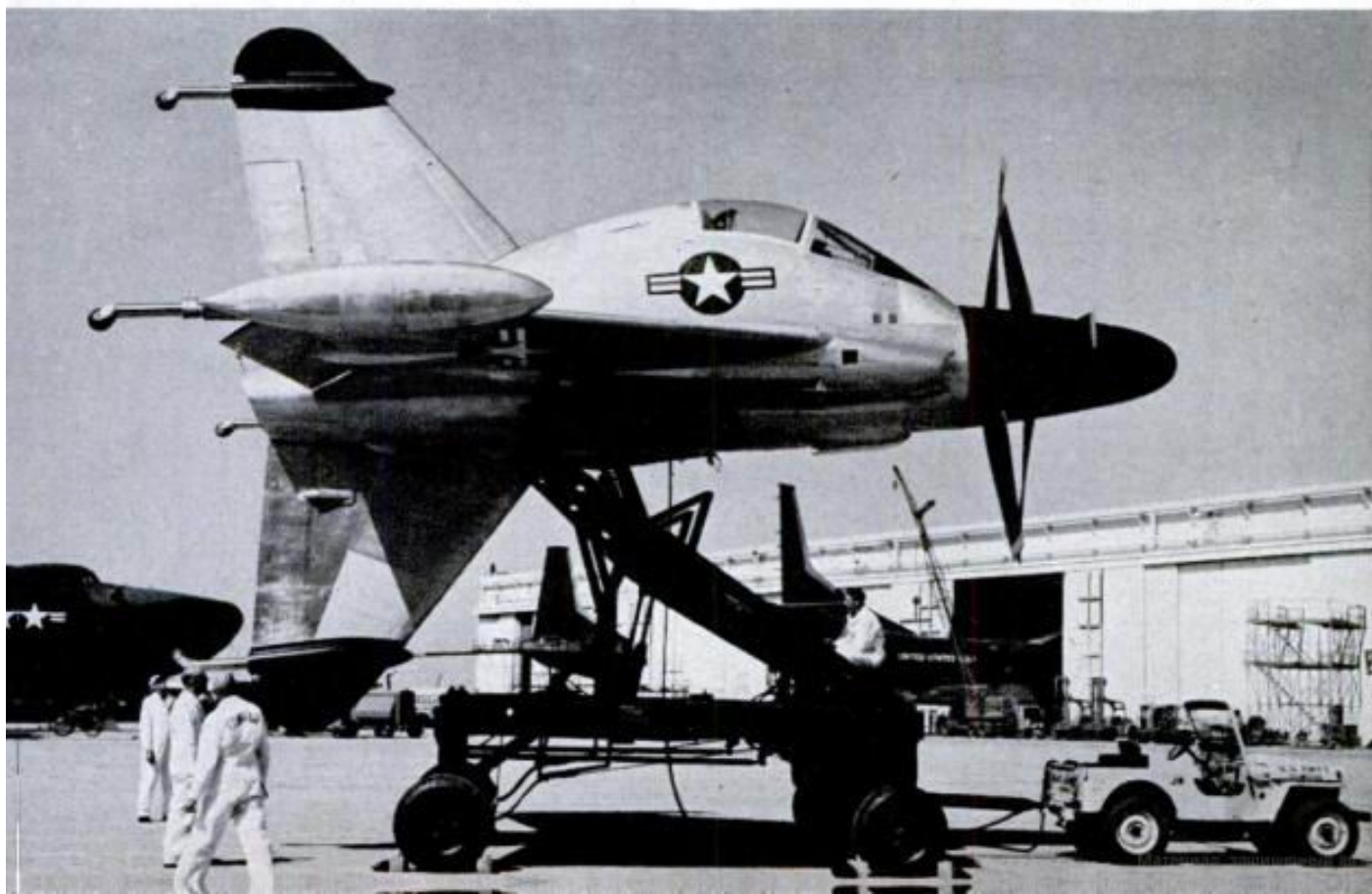
The obvious significance of these straight-up planes, however, is that they could be based on practically any type of Navy ship, and, in time of war, even on merchant ships with the addition of a small platform at the stern. Thus a ship could carry its own aerial protection, and a convoy could send up a vast umbrella of fighter cover in a matter of minutes.

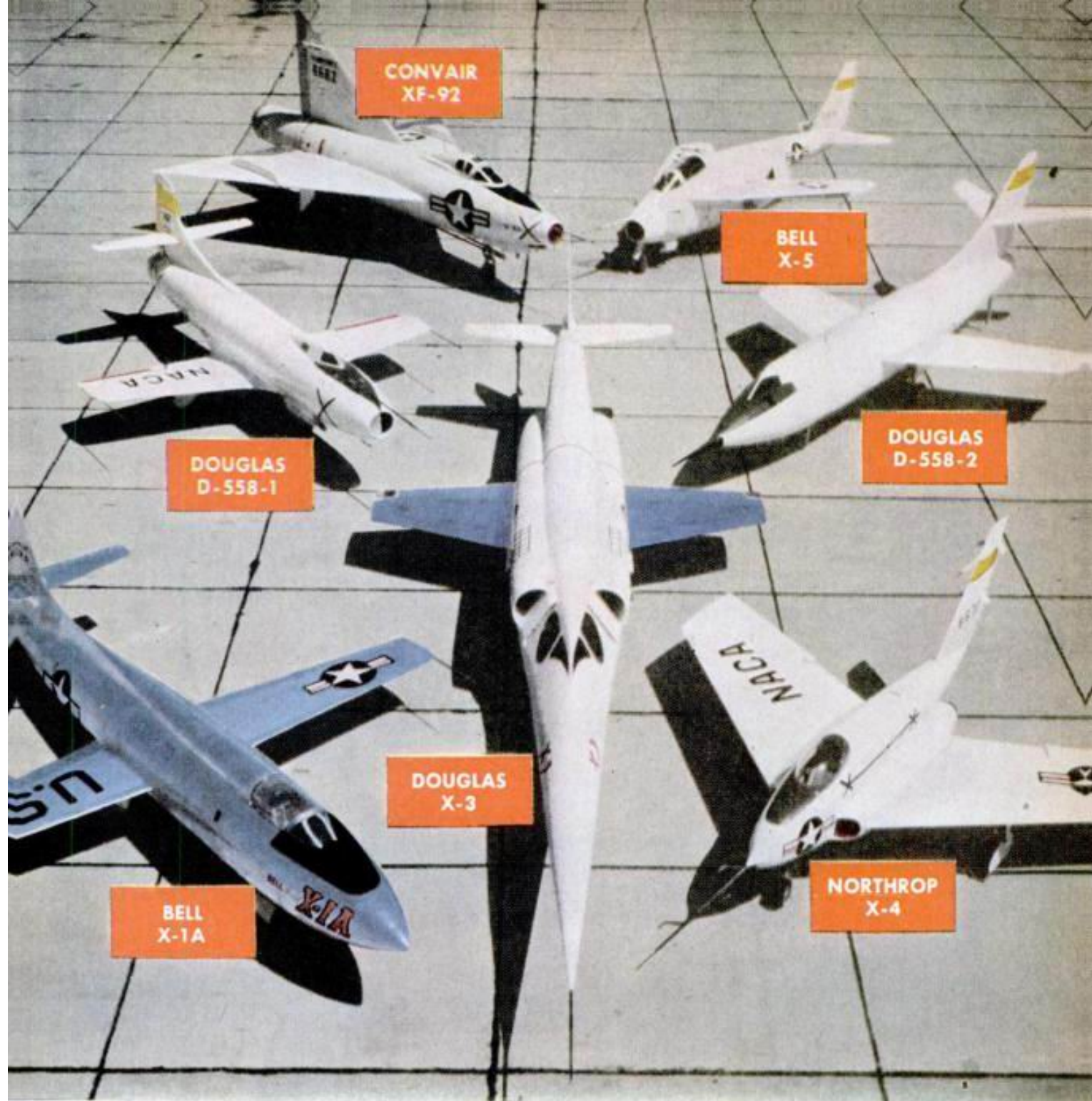
Propeller power probably will keep

these pioneer planes below supersonic speeds, but vertical-take-off pure jets are known to be under construction.

These "vertiplanes" are not to be confused with "convertiplanes," which use one system of propulsion to take off and land vertically like a helicopter, and another system for forward flight. For the latest news on convertiplanes, please turn the page.

Seen in normal, level-flight position, Consolidated Vultee's XFY-1 is a fat, stubby job.





Fast Company: These odd-looking speed champions, each built for a specific research project, are lined up at California's Edwards Air Force Base. There recently the one at lower left, the Bell X-1A, set a new unofficial speed record of 1,650 miles an hour. During that spectacular flight the plane, piloted by Maj. Charles E. Yeager, tumbled nearly 10 miles before it was again brought under control.

As to the others: The Douglas D-558-1 Skystreak set a world record back in 1947, going more than 640 miles an hour. Six years later, its more powerful brother, the D-558-2 Skyrocket, was the first

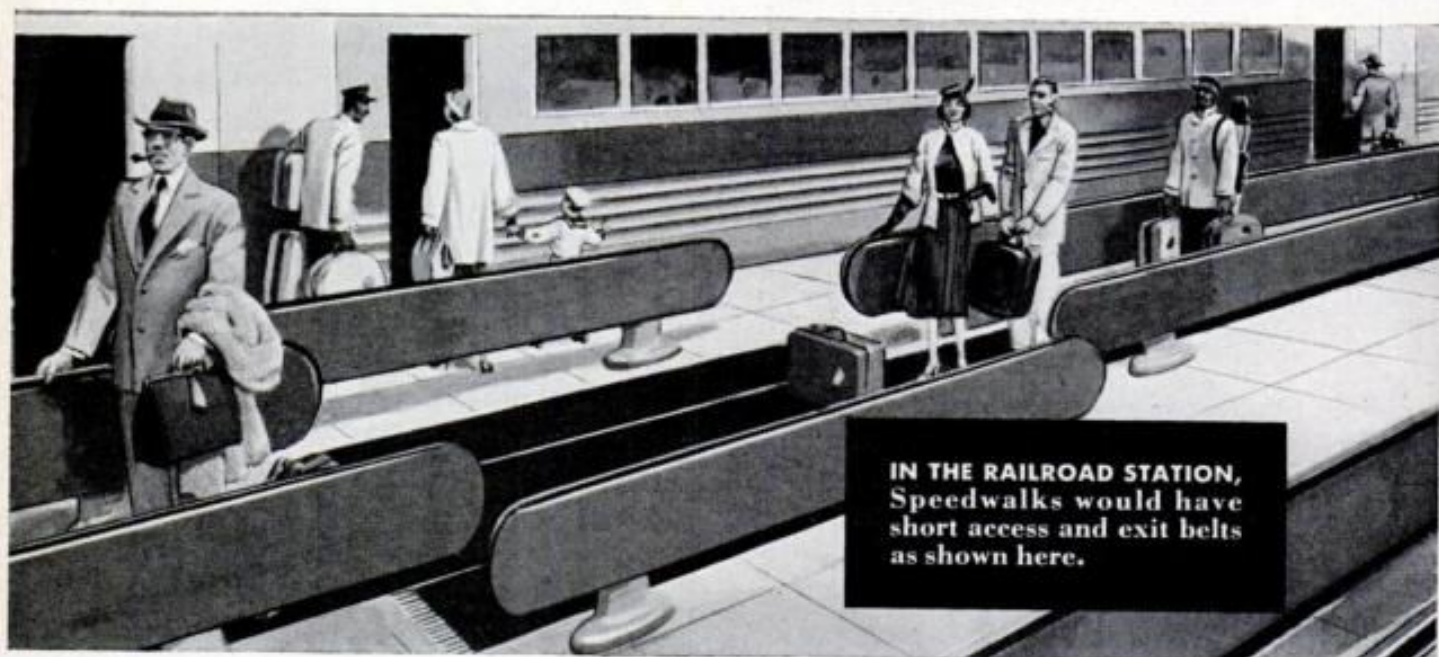
plane to fly at twice the speed of sound—1,327 miles an hour. It can fly higher than 80,000 feet.

The XF-92 was built to test delta-wing configuration and the X-5 to study the effects of changing the degree of wing sweep in flight. The latter was recently destroyed in a crash. The X-4, a relative slowpoke in the field, was designed for swept-wing research at subsonic speeds.

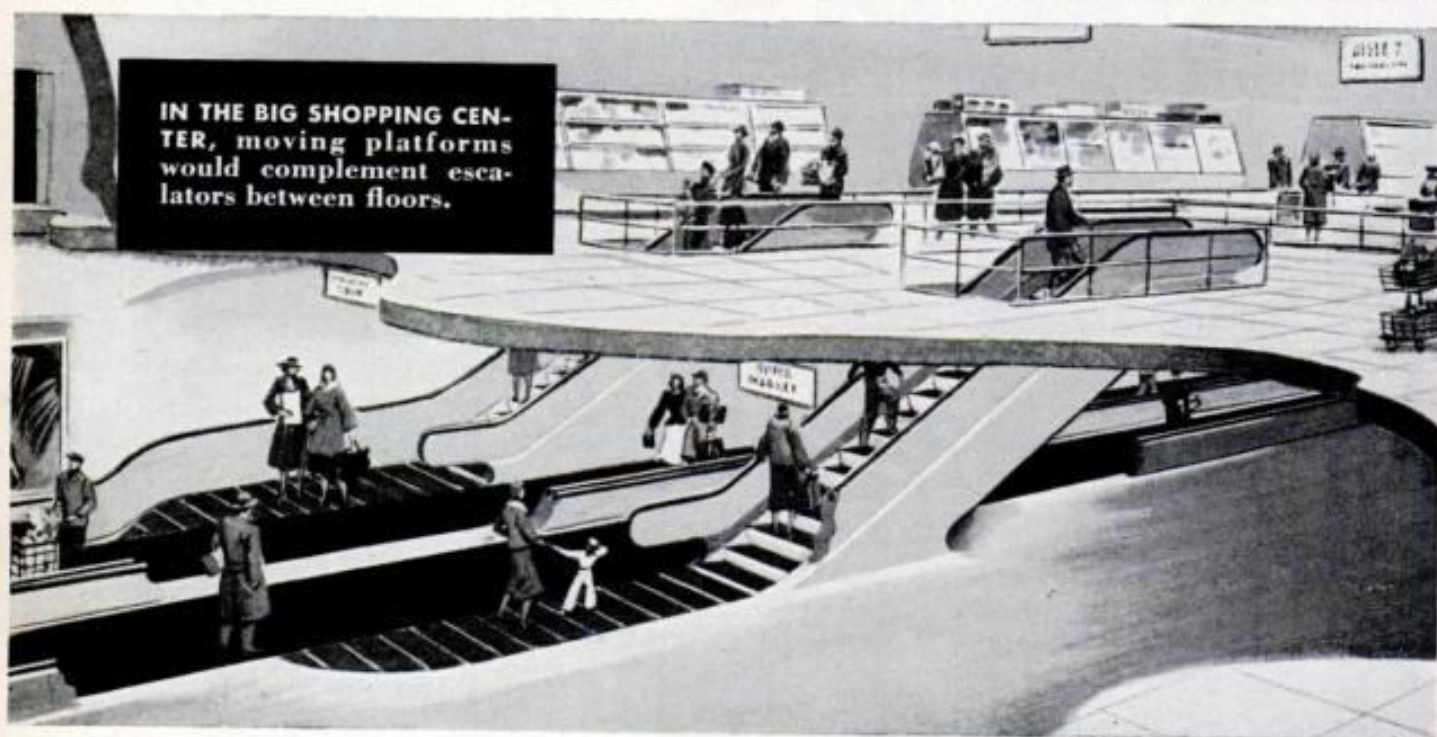
In the center is the "flying stiletto," probably the speed champion of them all, although its supersonic performance has not been announced.



AT THE AIRPORT OF TOMORROW, passengers would ride moving belts and escalators.



IN THE RAILROAD STATION, Speedwalks would have short access and exit belts as shown here.

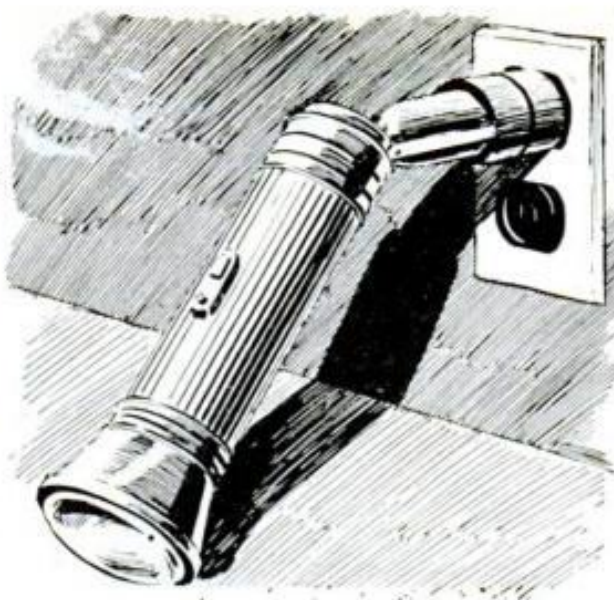


IN THE BIG SHOPPING CENTER, moving platforms would complement escalators between floors.

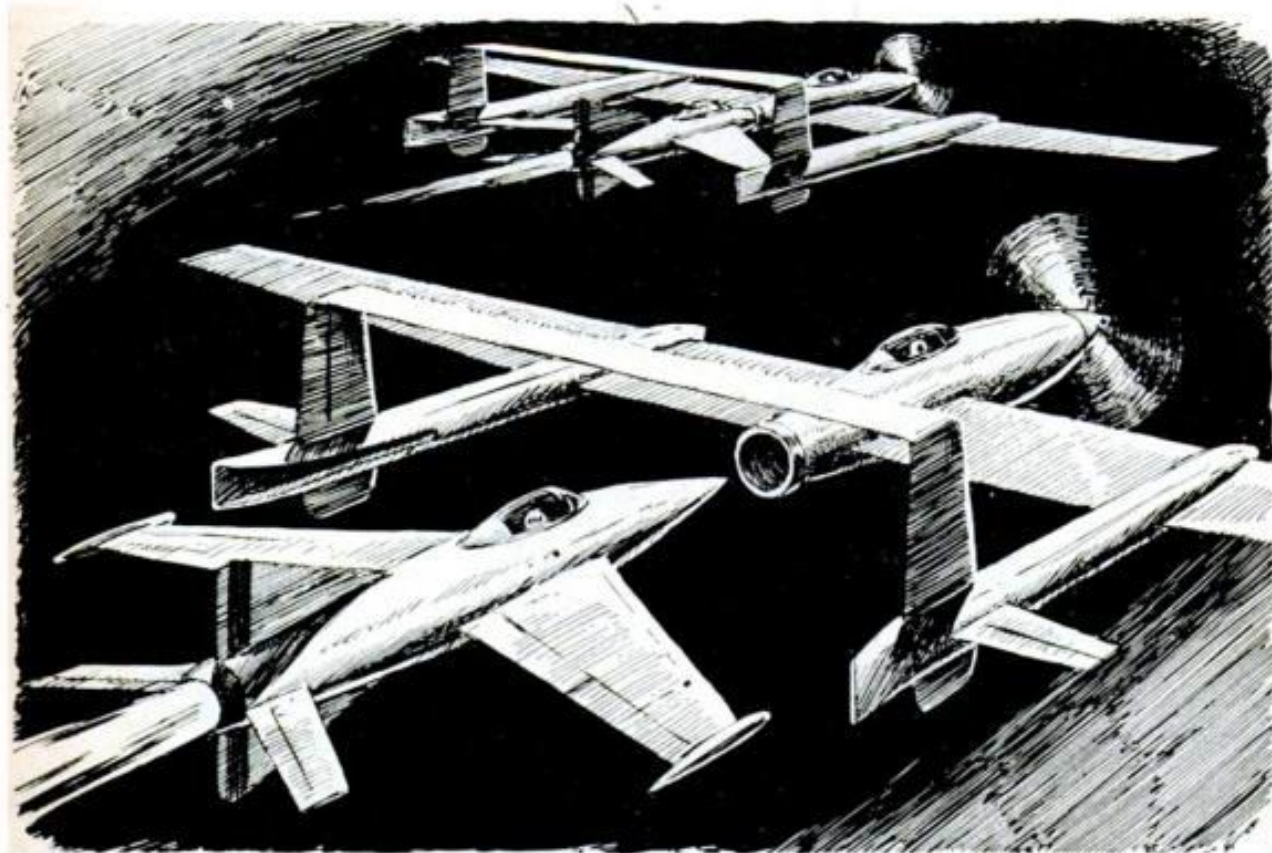
MORE New Ideas from the



4 Bumper Guard to Deflect Car. Side-swipes and even head-on collisions might do less damage if cars were equipped with these deflecting guards. The rigid channel, bent in a broad arc, would be bolted to either or both sides of a bumper. If the car rammed an obstacle, the guard would tend to shove the car sideways.



5 Flashlight to Be Recharged. A new set of flashlight batteries would be as near as a wall plug if your torch were powered by a wet cell and had a built-in charging unit. This standard-size flash would have a rechargeable battery and a rectifier assembly that would slide out of the case and plug into any AC or DC outlet.



6 Fuselage to Form Second Plane. A plane intended for high-speed flight usually has to be carried aloft and launched at suitable speed. According to this French invention, the carrier and carried plane could form a single airborne unit. After the

composite plane passed the minimum flying speed of the high-speed subsection, the mother plane would accelerate to pull away from its passenger. The small unit could rejoin the carrier by flying in behind it and locking itself in position.



If Your House Were

**Official tests show \$40 basement
Even your car offers some**

JUST at dawn, one morning recently, you and the house you live in and the car you drive were atom-bombed. It was done by proxy in a nuclear-device test shot at the Nevada Proving Grounds near Las Vegas.

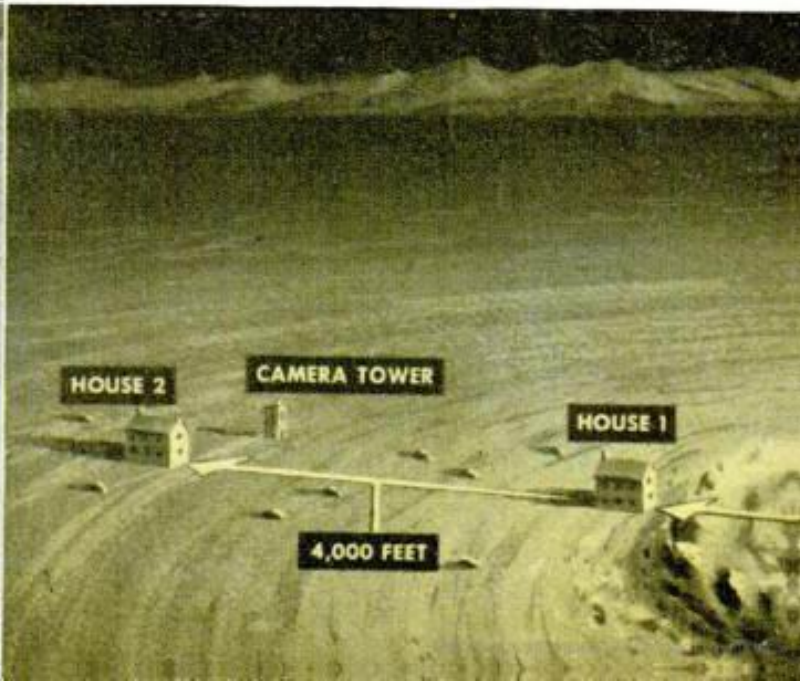
Your home was accurately represented by two neat white frame houses of which a twin could be found in almost any American block. They were colonial houses of standard construction, the kind you'd pay about \$20,000 for.

Among the 59 automobiles within two miles of the explosion that morning were cars closely resembling in color, model and make the one in which you might find yourself if an enemy bomb dropped.

Representing you and your family were department-store dummies. Whether a bomb attack found you in bed, at

◀ The Setup

Typical colonial house, with cars parked in yard, awaits blast 7,500 feet away. Another just like it is only 3,500 feet from bomb. Cameras in nearby towers will record how they take it. Store dummies represent family in dining room and basement shelter.



A-Bombed

**shelter might save you.
protection—if you duck quick.**

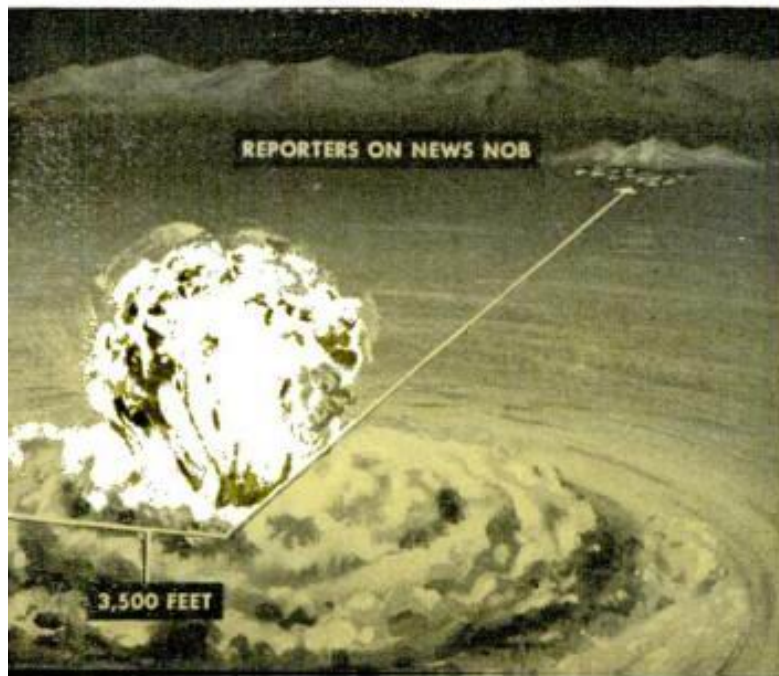
the dinner table, in your car or protected by a homemade basement bomb shelter, your situation would be accurately represented by one or more dummies.

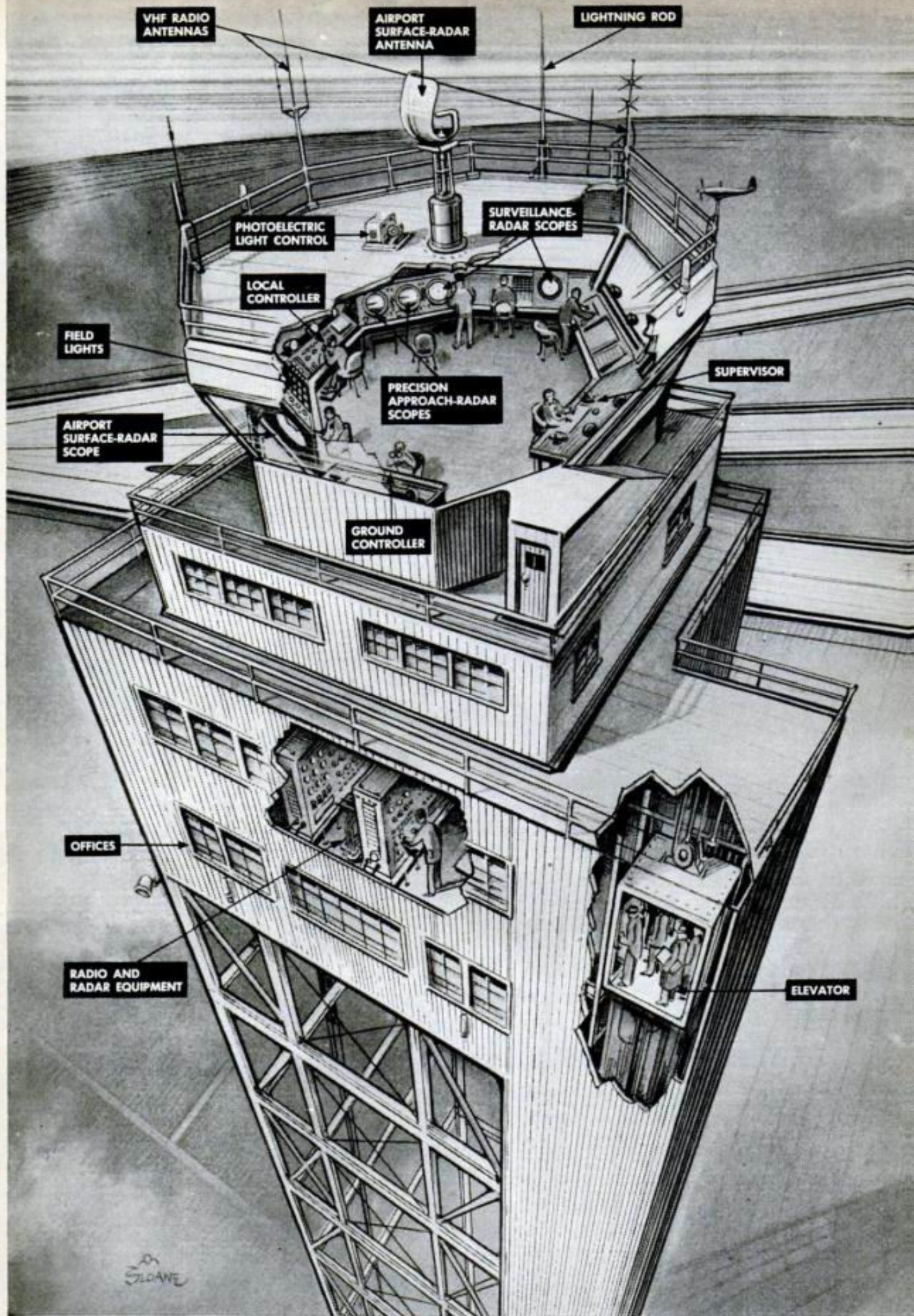
Beginning as soon as two hours after the great flash illuminated the Nevada desert, official observers began to examine the still-radioactive houses and cars. Their purpose was to learn what you could expect, what rescuers might run into and, above all, what you could do to protect yourself. Other expert inspections continued on the following days.

Some of what happened in a few seconds to stand-ins for you, your home and your car will not be clear for months. Other things became apparent quickly. It was to put these facts to work at once that some 600 civil-defense authorities,

What Happened

High-speed movies show nearest house disintegrating in two and a third seconds: Bomb flash lights scene, house bursts into flames, blast wave blows out fire almost immediately, structure is ripped into kindling. But dummies in basement shelters were unharmed.







HELICOPTER VIEW of skyscraper control tower in middle of New York's vast Idlewild Airport shows open framework where it will be connected to passenger and freight buildings. Photoelectric control (drawing, left) automatically switches on red warning lights atop buildings when visibility is poor.

Supertower to Direct New York Air Traffic

An 11-story building in the middle of one of the world's largest airports will use new electronic aids to help planes land safely.

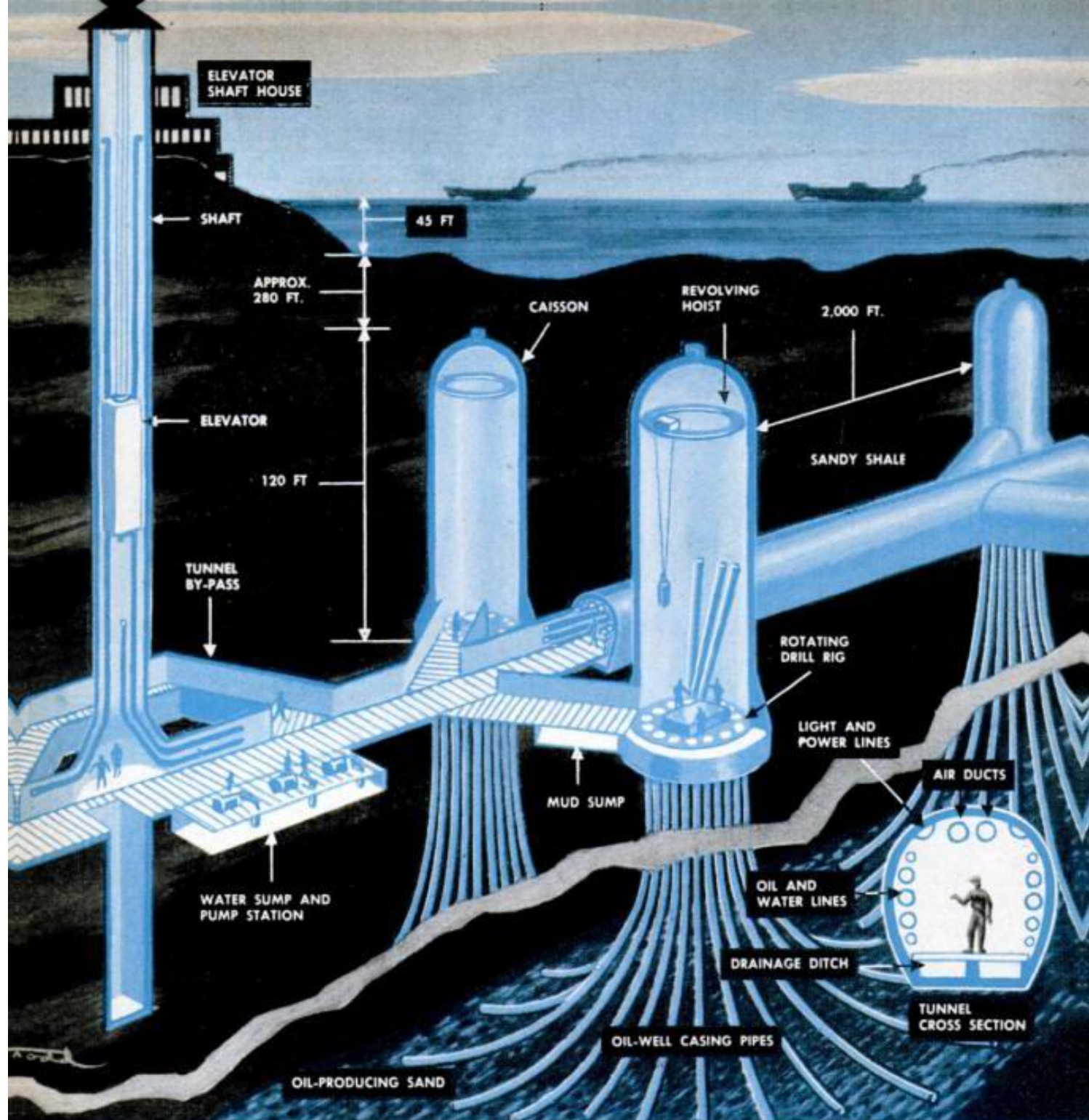
By Carlton Bucher

ABOUT the last thing that an airplane pilot wants to see in the middle of an airport is an 11-story building. That's exactly what is on New York's Idlewild airport—one of the world's biggest, with a capacity of 1,000 airliners a day.

The building is a new control tower. It had to be put in the center of things and

be built that high so the controllers could see to the edges of the 4,900-acre field. Under low ceiling conditions the top of the tower is lost in the clouds.

For moving more planes safely in and out in bad weather, the new control tower will be equipped with every known device to spot an incoming airplane miles away, follow its movements while the pilot lines himself up with the Instrument Landing



Tunnels to Tap Undersea Oil

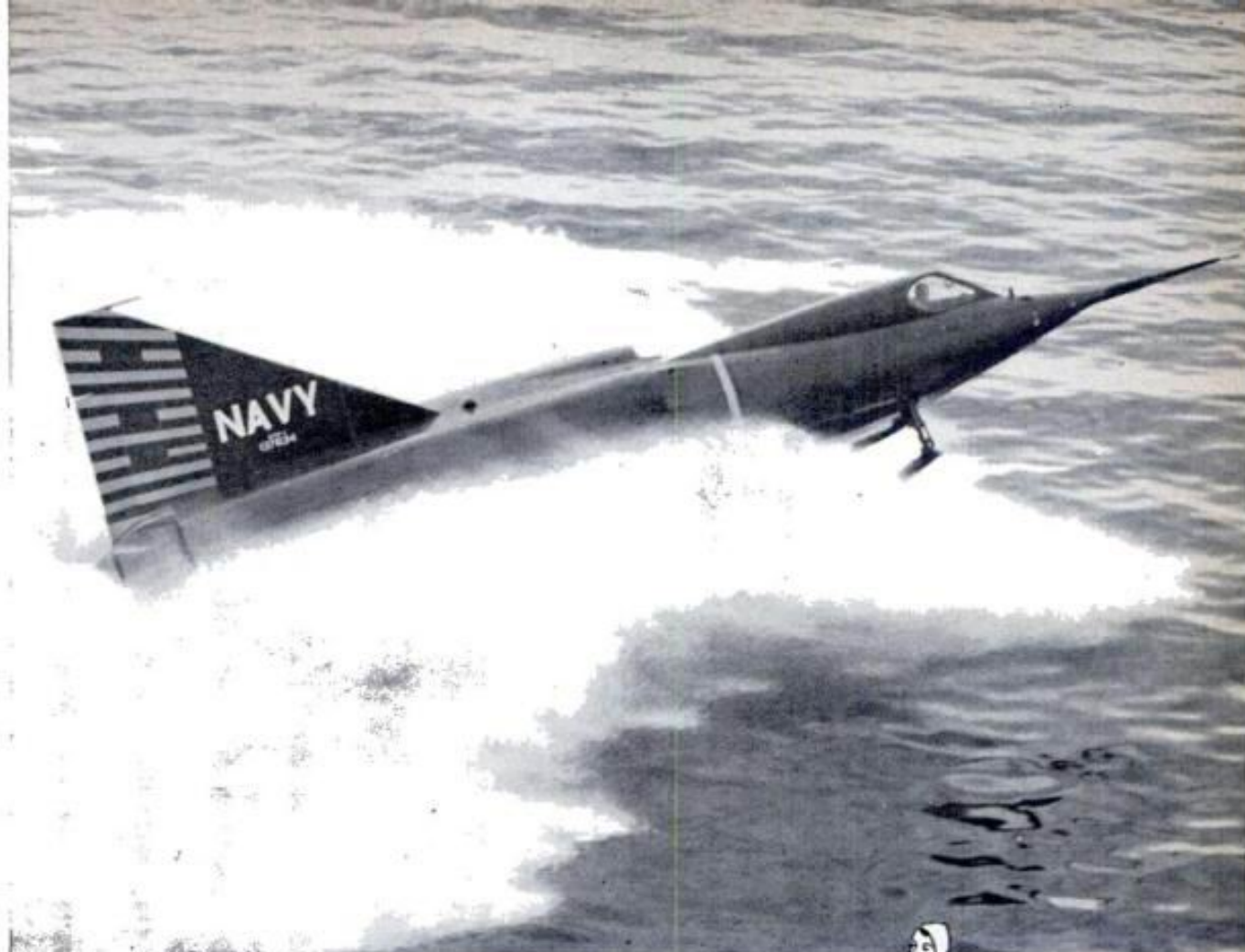
HOW do you get at forty billion gallons of oil hundreds of feet below the sea without blocking a busy harbor?

That was the \$100,000,000,000 question—the approximate value of oil under the ocean near Long Beach, Calif.—until engineer-geologist Hillman A. Hansen came up with the proposal shown above.

The plan envisions a vertical shaft on

shore. From its bottom, a network of tunnels would be dug out under the water, about 400 feet below the sea bottom.

At the ends of the tunnels, caissons would be constructed to give working space, full-size drill rigs would be brought in, and the digging would start from there. A number of wells would be sunk from each caisson, fanning out in a circular pattern. By whipstocking—slanting the drill—each well could be placed exactly where desired. Twenty wells from a caisson would serve 100 acres of the sub-sea oil field.



World's first hydro-ski jet fighter breaks water in taxi test.

***A patch of water becomes a runway
—ready-made and bombproof—
for this new kind of seaplane.***



Jets on Skis Can Use Oceans for Airfields

By Herbert O. Johansen

COULD a submarine refuel a supersonic jet fighter in mid-ocean? It sounds silly. How would you get the submarine up in the sky? Or the fighter down to the submarine?

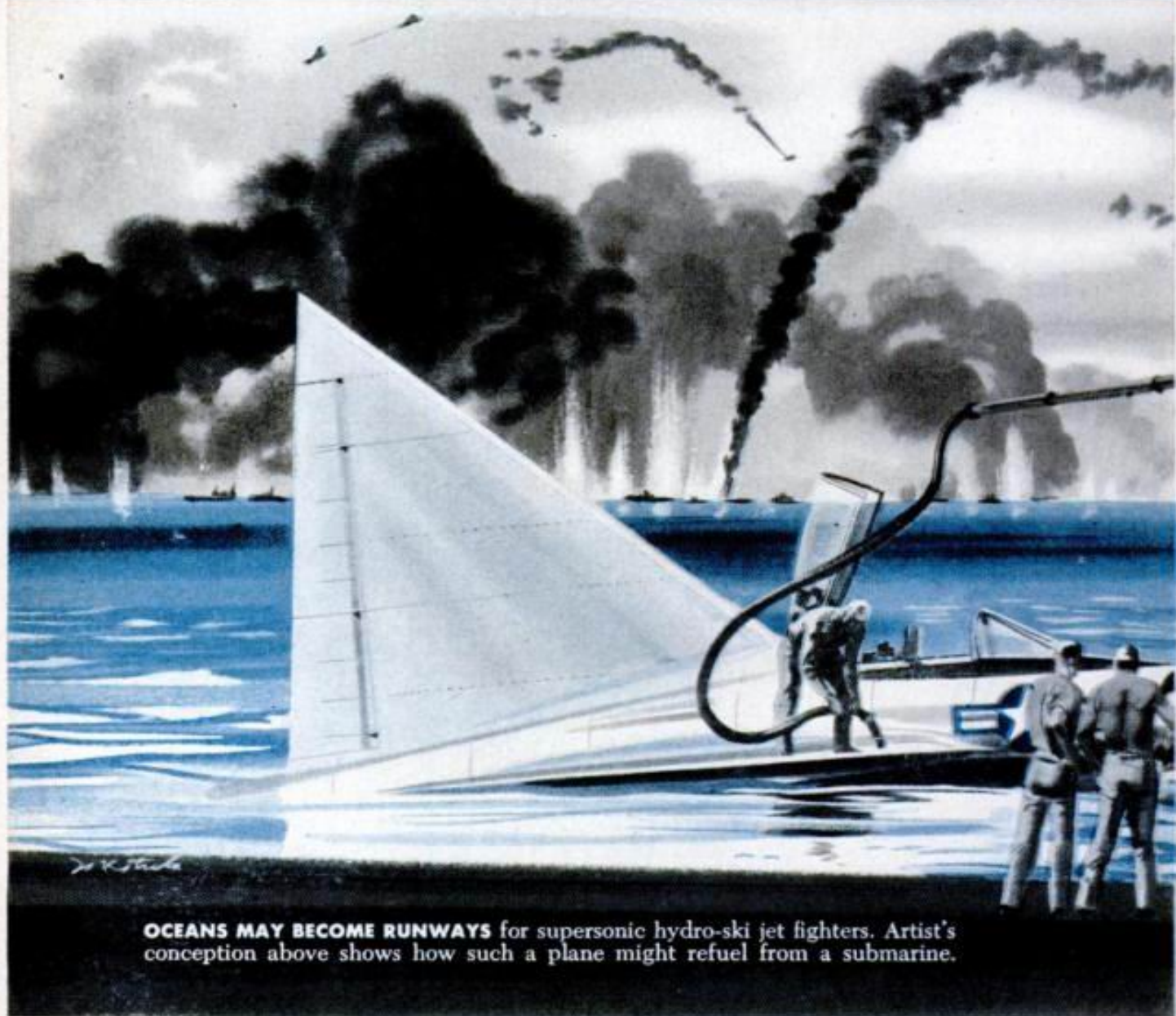
A way to use the sea's vast surface as

a field for a faster-than-sound fighter plane has been found now by the U. S. Navy. The plane is the Convair XF2Y. And the device that is expected to make the jet a seaplane—and possibly revolutionize aviation—is a thousand or more years old. It is a ski such as ancient Lapps used to skim over snow, and

How Hydro-Ski Jet Fighter Takes Off

SKI GIVES
UNDERWATER LIFT...

... BOOSTS PLANE BODILY
OUT OF WATER...



OCEANS MAY BECOME RUNWAYS for supersonic hydro-ski jet fighters. Artist's conception above shows how such a plane might refuel from a submarine.

bathing beauties use right now to skim the waves behind speedboats in Florida.

The Convair XF2Y Sea Dart, shown on the preceding page trying out its hydro-ski gear during preflight tests in San Diego Bay, is a delta-wing, twin-jet job. It has no horizontal tail but a triangular-shaped vertical fin. When the plane is at rest on the water, the hydro-ski, projecting beneath the fuselage, is submerged. As the plane starts, the ski acts as a hydrofoil, giving underwater lift.

Suddenly, it boosts the craft bodily out of the water, nose up. Then, as the hydro-ski itself breaks through the surface with a short burst of fine spray, it becomes a planing surface, supporting the airplane on the water as it accelerates to take off.

When the plane is airborne, the hydro-ski will be retracted, like the wheels beneath a landplane, to eliminate air drag in flight. For a landing, the hydro-ski will be lowered in flight. As it touches



...SUPPORTS PLANE UNTIL
IT IS AIRBORNE...

...THEN RETRACTS
IN FLIGHT.

Berthing Hydro-Ski Airliner



WATER-TAXIING, plane noses one
float wingtip into buoy.



AS IT SWINGS AROUND, slowing
down, dock is extended.



COMPLETING CIRCLE, plane is
moored, passengers disembark.

the water and the plane slows down, the ski will take on more and more of the load. And when the weight becomes too great, the ski will submerge, allowing the airplane to float on the water.

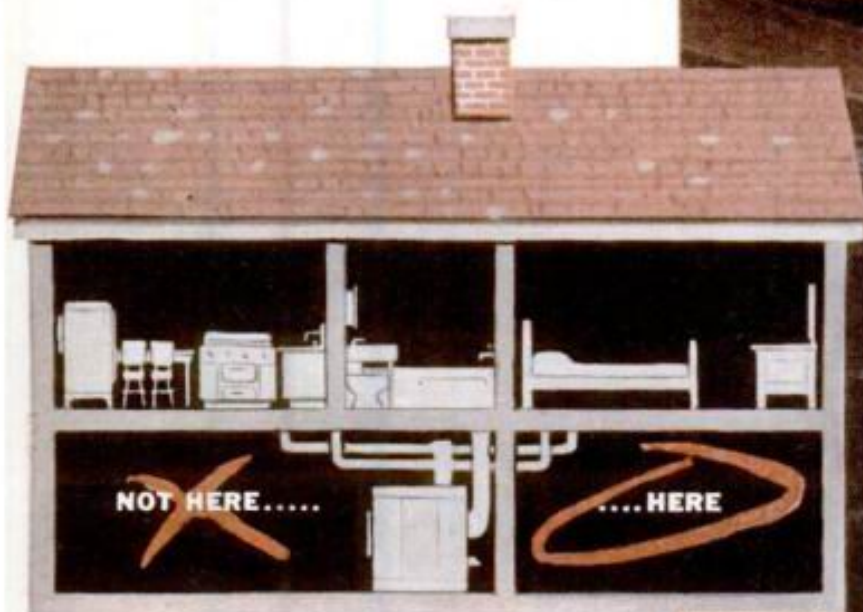
Glenn Curtiss built a flying boat 40 years ago. More recently, improved models carried transoceanic passengers. But land-based planes displaced the flying boats because they were faster. Now, jet engines make possible water-based planes without the bulky hulls which

dragged the old flying boats out of the picture.

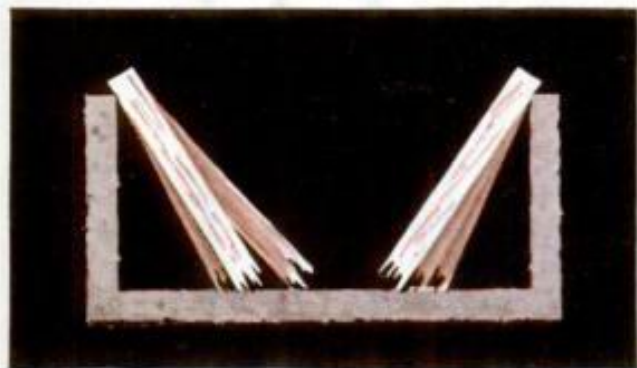
With jets, a high wing is no longer needed because there are no propellers to keep out of the water. A low wing can settle right down on the water and act as a float. The underside of the fuselage must be watertight, of course, but this is not a difficult requirement—and retractable wingtip floats can be added if needed.

Jets and hydro-skis have thus made a

What You Need in a Basement Foxhole

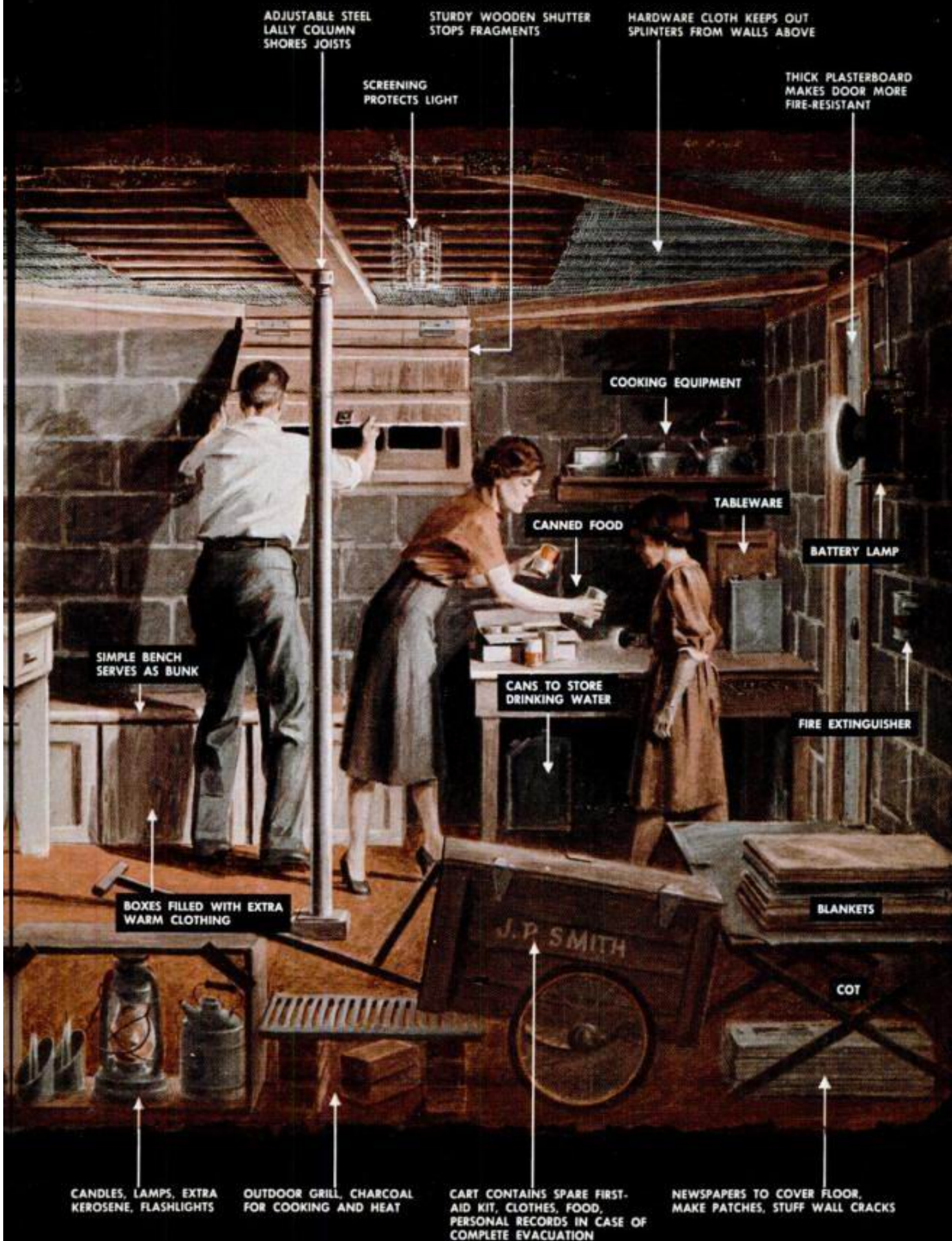


How well your basement refuge will protect you depends on how carefully you choose its location and equipment. As indicated in the drawing above, keep away from the furnace or oil tank (they might start a fire) and the kitchen or bathroom (their heavy fixtures might fall in on you). Outfit your foxhole for pioneer living. You may have to cook over a charcoal fire, jellied-alcohol burner, or kerosene-lamp stove. You shouldn't count on any utilities except possibly gas (the mains, deep underground, are reasonably bombproof). Water pressure may drop after a raid. The water is not likely to become radioactive, but may be polluted. So fill all available containers before the raid; water obtained after the raid should be boiled or purified with chlorine tablets. Telephone service, if not dead, will be badly jammed with emergency calls. Electricity is almost sure to be lacking.



Drawing above shows why floor near outside wall is safest place in cellar if joists fall in. But upstairs, interior partition walls are safer.





Turn the page, please, for more tips on survival.

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If your house has no basement, bank earth or earth and logs against an outside wall. Put a heavy table next to that wall on the inside (inset) to catch beams if any should fall.



Safest place in basement-less home is also under table. But not near outside wall, as in cellar refuge. Choose interior, non-load-bearing partition, which is least likely to collapse.



Gully outdoors may offer more protection than lightly built, basement-less house. Lie face down, with head in crook of arm. Do this, too, if you're caught outdoors by a burst.



Underground shelter in yard may be advisable, particularly if big windows, lack of basement leave house too open. Build shelter carefully, with adequate bracing, drainage, exits.



INSIDE SCREENS STOP FLYING GLASS

CANS MAKE REFLECTORS, STOVE CHIMNEY



CHOOSE CANNED FOODS CONTAINING LIQUIDS, FOR WATER MAY BE SCARCE

PUT DECORATIVE ACCESSORIES TO WORK COOKING



Simple preparations, such as those suggested in drawings above, can help a great deal. Put screening inside windows—flying glass can be as dangerous as bullets. Keep extension cords han-

dy for the return of power. Until then, candles in tin-can reflectors and kerosene lamp made into stove with can chimney will serve. And Colonial fireplace accessories can help cook.

Check List of What You Need in Your Refuge Room

Tools and Equipment: Jackknife, pick, shovel, Boy Scout type of hand ax, crowbar, hammer, saw, pliers, adjustable steel lally columns (to support first-floor joists), wrenches, extra door bolts, hinges, padlocks, wallboard (for covering broken windows), extension cords, lamp sockets, bulbs.

Medical Kit: Salves for burns, gauze bandage, compresses, adhesive tape, splints, chlorine tablets (for purifying water), mechanic's soap (for washing off possible radioactive dust).

Fire-Fighting Equipment: Hand extinguishers, stirrup pump, empty buckets, buckets of sand, buckets of water, garden hose (with coupling for attaching it to indoor faucets).

Lights: Battery-powered lights, kerosene lamps, candles, drop light.

Food: Canned food (choose fruits and vegetables packed with liquid), bouillon, dried milk, powdered cocoa and coffee, raisins, chocolate, dried fruit.

Cooking Equipment: Skillet, teakettle, covered pot, can opener, brazier, charcoal, bricks and grate (for improvised fireplace), fireplace fittings (so you can cook in regular house fireplace), jellied-



alcohol stove, extra cans of jellied alcohol, outdoor grills, clean five-gallon cans, waterproofed matches (in tin box or dipped in wax), kitchen soap, scouring powder, steel wool, basic chinaware.

Clothing: Underwear, socks, old coats, coveralls, overshoes, rubbers, boots, old gloves, rain coats, waterproof fabric, sweaters, jackets, bandannas (for radiation or smoke masks).

Furniture: Heavy tables, bunks, benches, wheeled cart (for basic evacuation kit), packing boxes, trash cans with lids, duckboards (for damp floor).

Valuables: Extra pair of glasses, lockbox (for valuable papers), money (in small bills).

Miscellaneous: Battery radio (car radio will also work), wind-up clock, maps of city and county, books, writing materials, eye goggles (for smoke or radioactive dust), old newspapers.

POPULAR SCIENCE

MONTHLY

MECHANICS AND HANDICRAFT 

Wilbur Shaw Drives
New Small Buick



25¢ March, 1951

*Russian Guns:
How Good?*



Save this Issue:

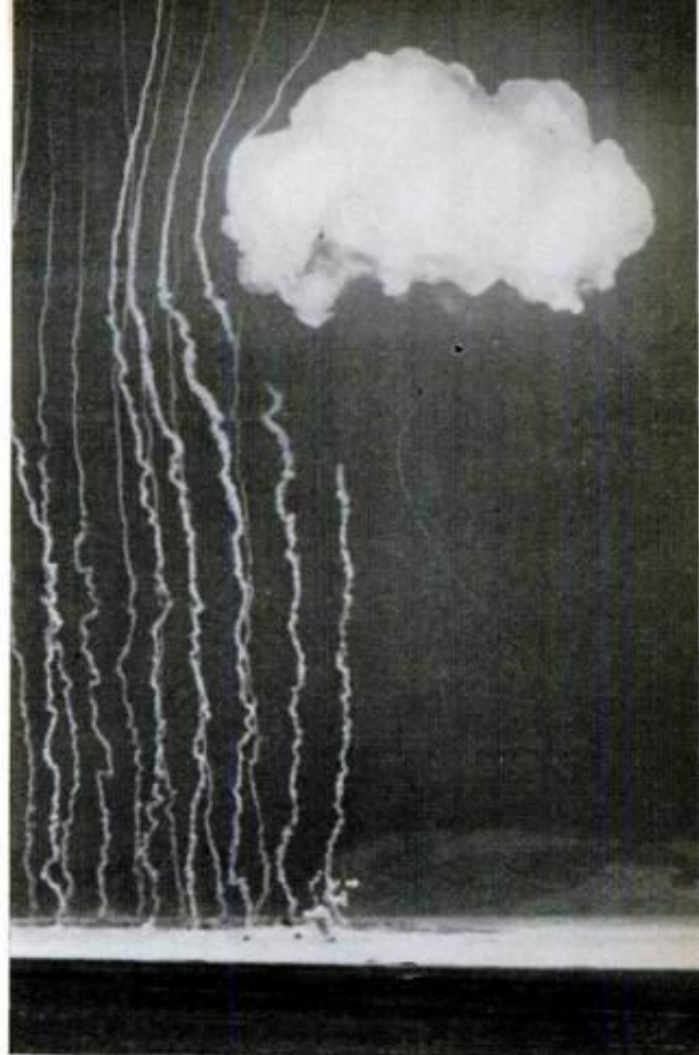
How to Build

A "Family Foxhole"



How New A-Bombs Are Tested Safely

ATOM BOMB at right exploded April 22. Smoke streamers from rockets help gauge spread of fireball. Artist Reynold Brown's impressions of this scene, sketched on the spot, appear on the next two pages.



The experts have a slot machine in Nevada that pays out information when the deadly bombs are dropped into it.

By Volta Torrey

ONE atom bomb in Japan killed and wounded more people than there are in the whole state of Nevada. But even more powerful atom bombs now can be exploded over the heads of troops in Nevada without so much as singeing a man's hair.

This can be done because the Atomic Energy Commission has built a huge, new kind of slot machine in Nevada. It is 16 miles wide and 40 miles long. In this desert tract, there are 2,200 miles of signal lines, 110 miles of power lines, 100 miles of paved roads, a telephone network, towers up to 300 feet high, and dugouts that cost up to \$600,000 apiece. All told, about \$8,600,000 has been spent to turn this small part of America into a safe place for experimenting with new atomic weapons.

When an atom bomb is dropped into the slot, cams turn, lights flash, instruments

click, the mountains recoil and rumble. Even the desert plants catch fire as a mountain of dust rises toward the fireball that finally forms a smoke ring and floats away. Then men in cars, planes and helicopters plunge into the dust to collect nuggets of information.

A Bull's-Eye from Six Miles

The bombs are dropped into a bull's-eye of white (lime) and black (asphalt) rings around a white X on the flat, brown desert floor. It is a target several hundred feet wide, which a bombardier can hit every time from an altitude of six miles.

Before a bomb leaves a plane, a few fenced-in acres 10 miles from the target hum with activity. This is the control center of the Nevada Proving Ground. It is the hub of an intricate and far-flung system of weather stations, the point from which the

[Continued on page 264]



Control Point for Atomic Experiments

This fenced-in area on the side of a Nevada mountain is the nerve center of the AEC's proving ground for atomic weapons. Instruments throughout the desert are operated from the building at right. This building is

about 10 miles from the point where the bomb shown here went off. Many of the objects which are shown clearly in this sketch could not actually be seen from the control point without binoculars.

How Atomic Bombs May Be Used on Battlefields

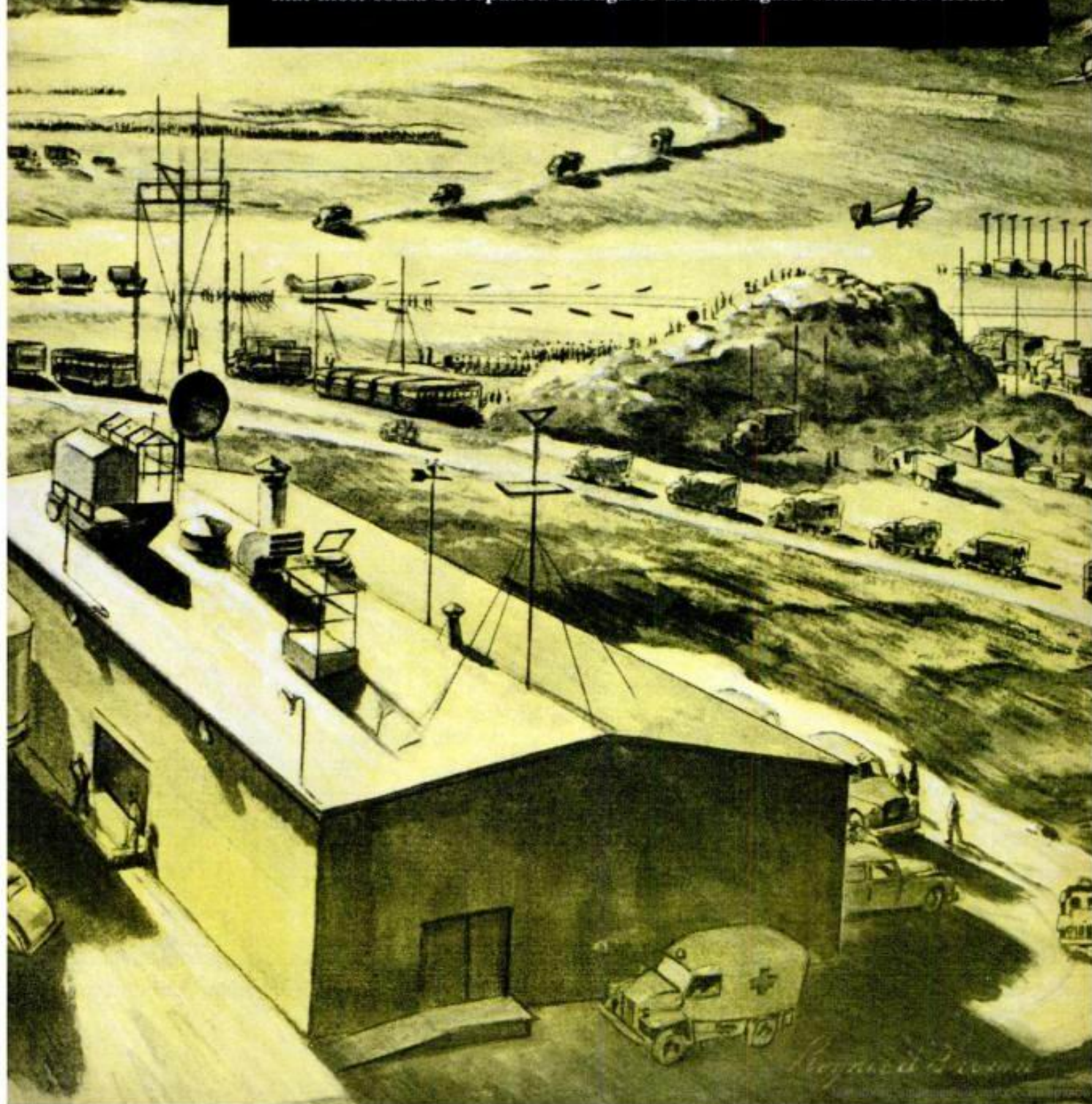
Last April 22, near Las Vegas, Nev., the U. S. Army experimented with an atomic bomb as a tactical weapon for the first time. This sketch made at the scene by Reynold Brown depicts part of that day's activity.

Civil-defense officials, newspapermen and TV cameramen were perched like monkeys on the rocks of the hill that you see below.

Soldiers crouched in foxholes between these observers and the target until a few seconds after the explosion. Then they climbed out and followed leaders with Geiger counters toward the target. They were asked to imagine that the target had been an important military objective in which the enemy was strongly entrenched, and which they were to attack and capture as quickly as possible.

While most of the troops advanced toward this objective, the paratroopers among them withdrew to planes in the rear, climbed aboard, flew around the cloud of dust to the far side of the target and dropped to attack from that direction.

Airplanes, tanks, jeeps, artillery and other military equipment were parked between the target and the men's foxholes during the explosion. Much of this equipment was damaged, but the advancing troops found that most could be repaired enough to be used again within a few hours.





ONE TV CAMERA will concentrate on fresh arrivals in the entrance hall.



MOBILE TV UNITS will meet incoming planes and trains and cover events in the streets.

RADIO BOOTHS

THIS FLOOR CAMERA WILL ALWAYS BE KEPT IN RESERVE

ZOOMAR LENS WILL MAKE ANY FACE IN THE HALL LOOK NEAR

CAMERA PLATFORMS ARE 12 TO 20 FEET HIGH AND 12 FEET SQUARE

WIRES FROM 55 FLOOR MIKES RUN UNDER FALSE FLOOR TO CONTROL PANEL ON SPEAKERS' PLATFORM



TO GET QUICK SHOTS outside, NBC will use the "walkie-talkie-lookie."



OUTLET TO THE NATION will be the microwave tower on top of the Illinois Bell building in Chicago. From here, 30 hours of TV will be telecast from each convention.

ABC

LIBERTY & MUTUAL

POOL

CBS

NBC

CAMERAS ARE ARRANGED TO COVER EVERY INCH OF FLOOR

How TV Will Take You to Conventions

One out of two Americans will see a President nominated in Chicago

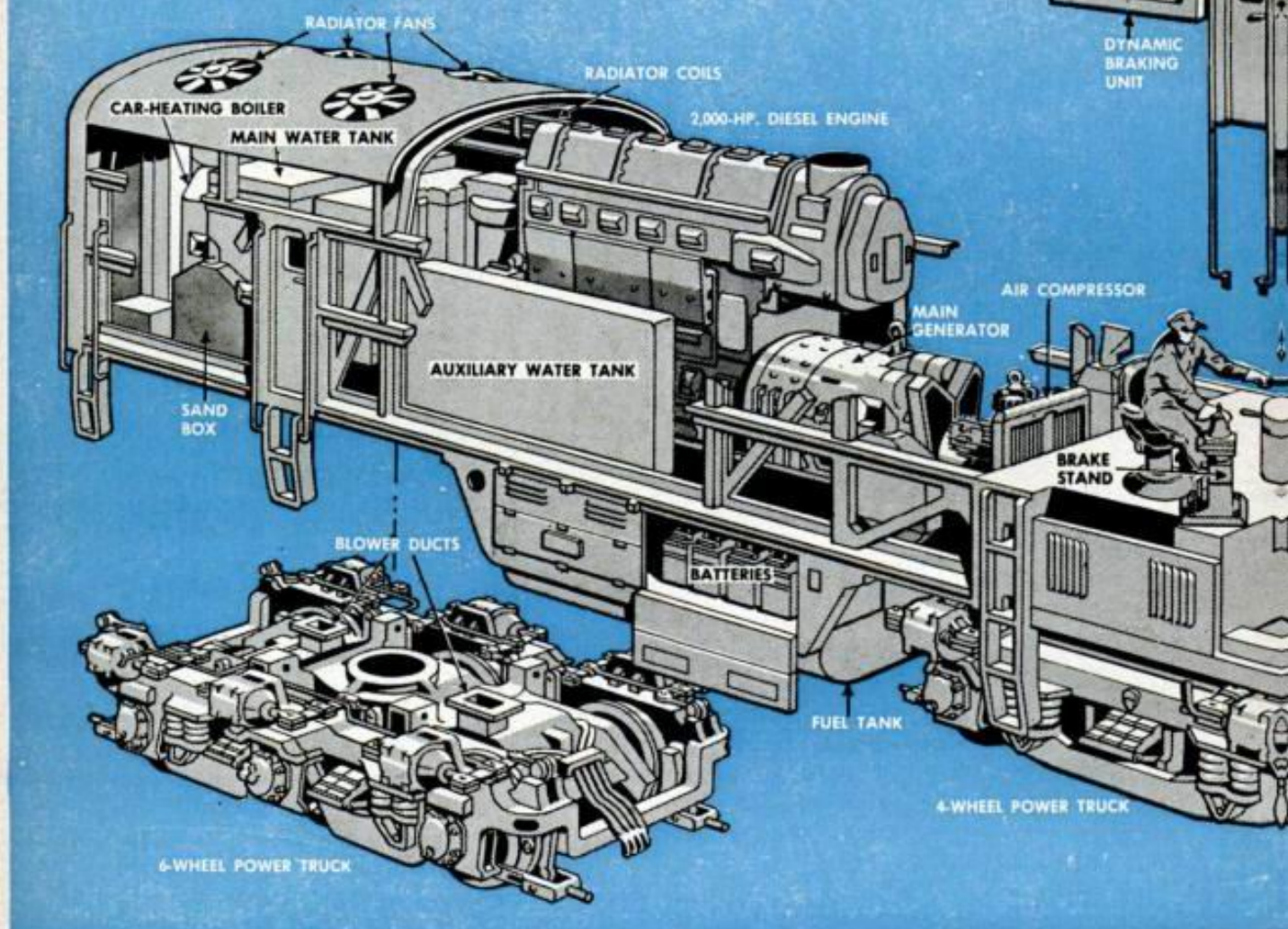
By Gardner Soule

SEVENTY-TWO million Americans will sit in on the greatest town meetings of all time—the Republican and Democratic National Conventions—at Chicago next month. The country's leading TV networks, with 1,000 cameramen, reporters, lighting technicians, writers, editors, film librarians and big-shot commentators on hand, will flash the sights and sounds of the conventions to all but four of the 108 U.S. television stations. Network officials estimate that one out of every two people in the country will see the political conventions on television.

Millions of dollars' worth of new and improved equipment, including the "walkie-talkie-lookie"

Are You a Diesel Detective?

This quiz will show you how to tell
at a glance a locomotive's make and job.



MANY railroad fans boast that they can identify any Diesel by the sound of the engine. But there are easier ways to tell who made it—General Motors, Alco, Baldwin-Lima-Hamilton or Fairbanks-Morse. And if your eye is sharp, you can deduce from the profile what type of service each one performs. You can test your ability by studying the numbered drawings at right.

Here are some clues:

Numbers 1, 2, 3 and 4 are all designed to meet the same requirements. Each is rated between 1,500 and 1,600 horsepower, but is the product of a different builder.

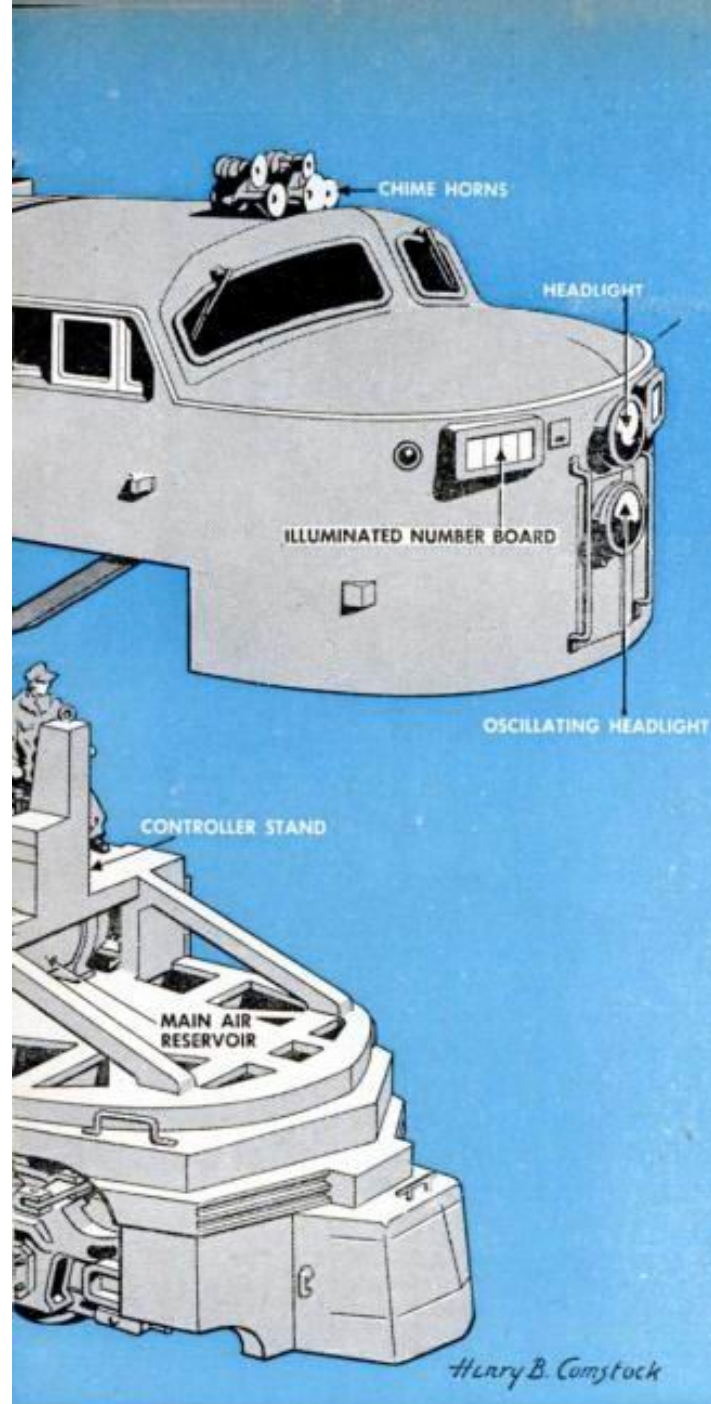
Number 5 is basically the same kind of locomotive but its stepped-in flanks and two sets of cab controls adapt it to a different type of work. All four builders manufacture

this line, but the rounded roof contours are peculiar to one.

Number 6 is actually two switching locomotives, permanently coupled together and controlled from a single cab. It is used in some of our largest rail centers. This articulated design is peculiar to one builder.

Number 7 is a 2,250-horsepower, two-engined version of a type made by all four manufacturers. Its bulbous nose identifies this one as a big brother of Number 4. The builders of locomotives 1 and 2 also turn out similar two-engined locomotives. The builder of No. 3 produces a comparable single-engined locomotive, which is shown in the exploded drawing above.

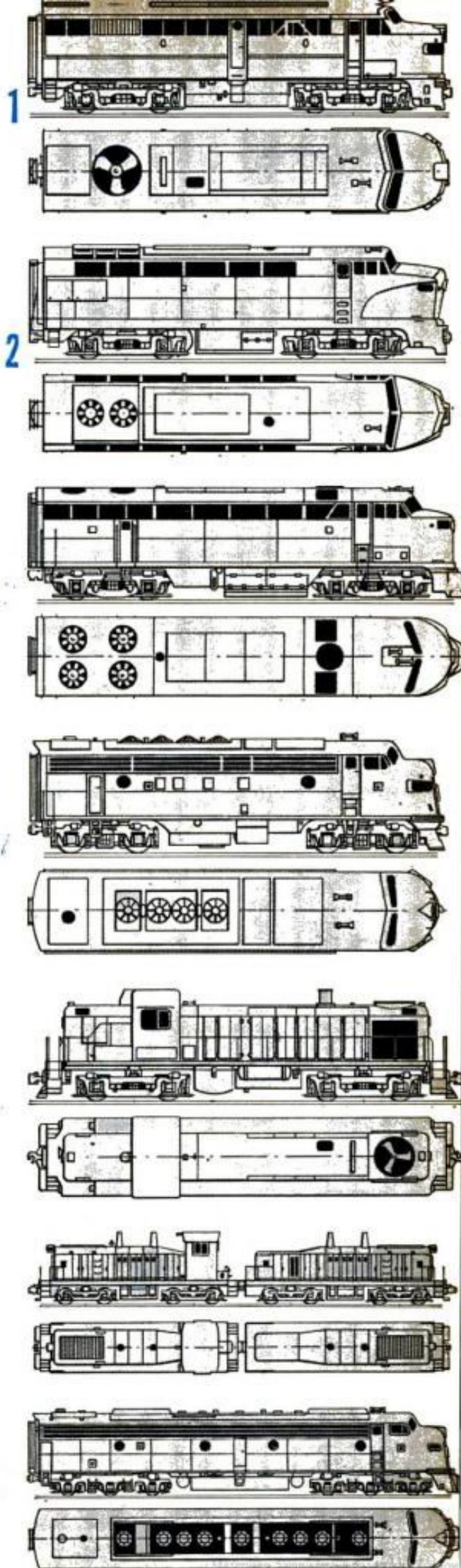
Now check your answers at right.—Henry B. Comstock.



Henry B. Comstock

WHO'S WHO IN DIESELS

Numbers 1 through 4 are road freight engines. By the addition of a car-heating boiler and a change of gearing, they may be used in passenger service. The builders are—in order—Alco, Baldwin-Lima-Hamilton, Fairbanks-Morse and General Motors. Number 5 is an Alco road-switcher type, equally at home in yard service or out on the main line hauling a short freight or a commuter train. Number 6 is a GM transfer engine. Its specialty is assembling heavy freight trains and hauling them to another yard. Number 7 is a GM passenger engine, more powerful—and therefore faster—than the freight haulers. The large drawing shows the Fairbanks-Morse version of the same job, with a six-wheel truck at the rear.



Russia's New 2-Jet Bomber

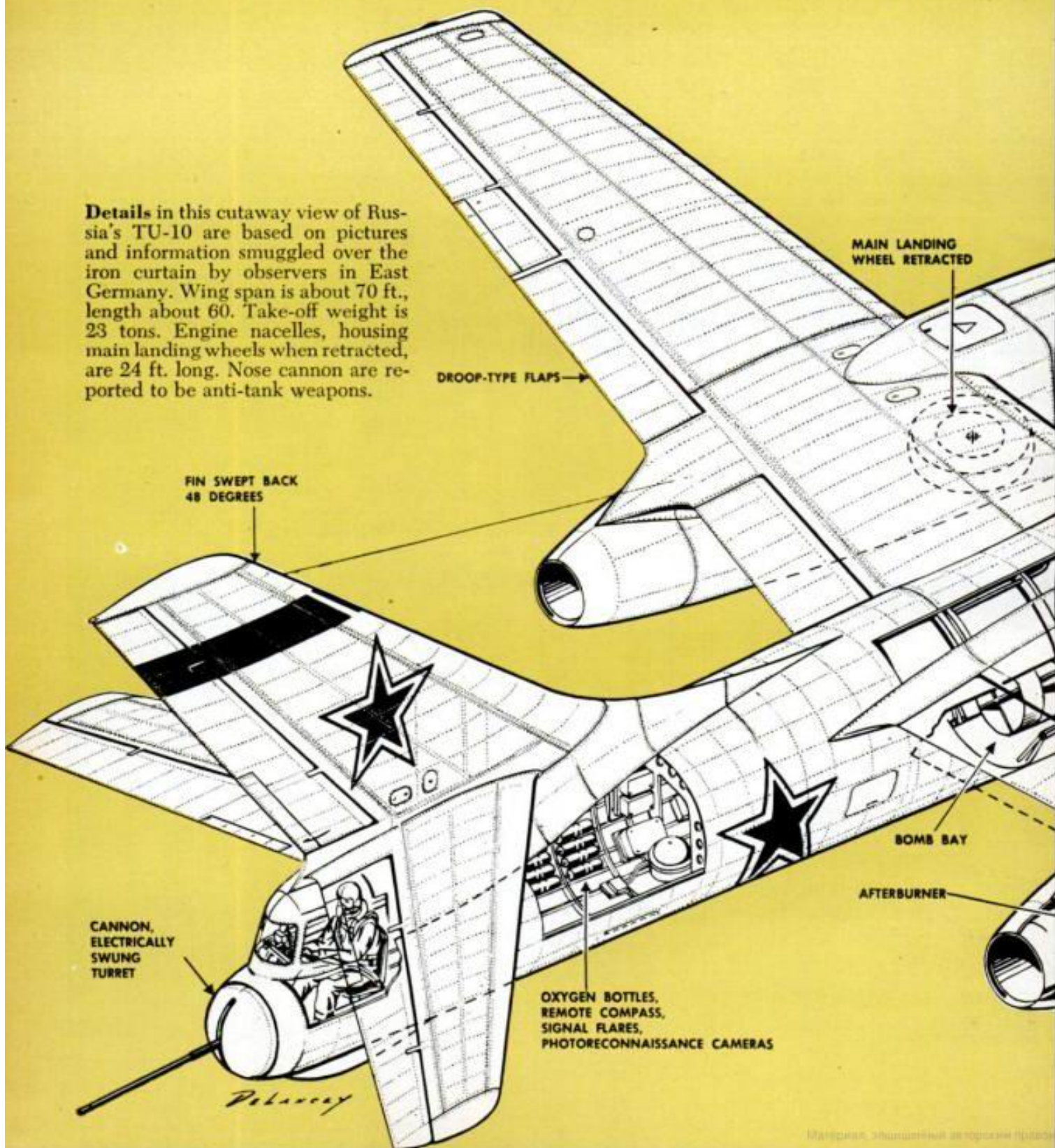
By Chalmers ("Slick") Goodlin
Noted Test Pilot

RUSSIANS in Eastern Europe are flying a fleet of brand-new, hot bombers. They were made for the express purpose of running interference for the Red infantry.

Powered by twin jet engines, the new plane is bigger, far faster and harder hitting than the propeller-driven Stormoviks with which the Red Air Force helped turn back Hitler's Panzer divisions. The Russians call it the TU-10.

Two items of the TU-10's equipment make it stand out. One is apparently the first Russian production version of a compact navigational-search radar installation.

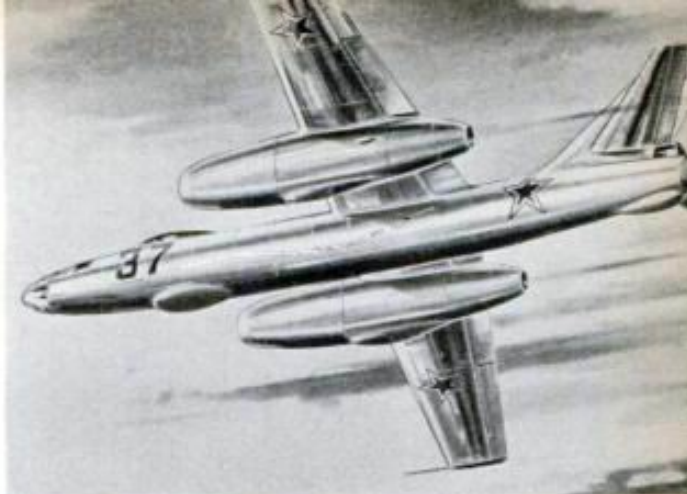
Details in this cutaway view of Russia's TU-10 are based on pictures and information smuggled over the iron curtain by observers in East Germany. Wing span is about 70 ft., length about 60. Take-off weight is 23 tons. Engine nacelles, housing main landing wheels when retracted, are 24 ft. long. Nose cannon are reported to be anti-tank weapons.



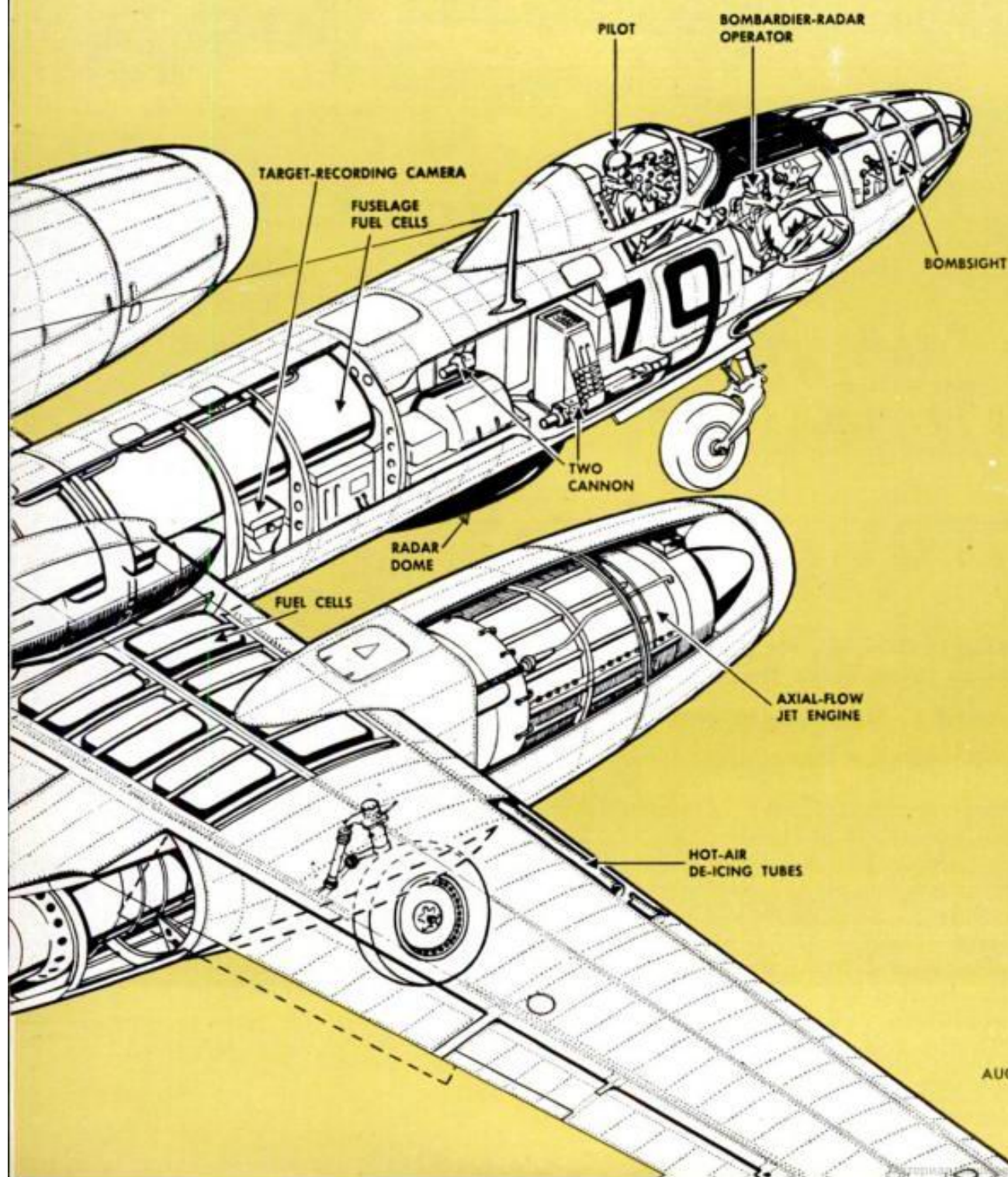
The other is a new jet engine, the M-018. It develops 7,700 pounds of thrust and has an afterburner for extra bursts of power. By way of comparison, the U. S. B-45 has jet engines of only 5,200 pounds of thrust but uses four compared with the Red Air Force bomber's two.

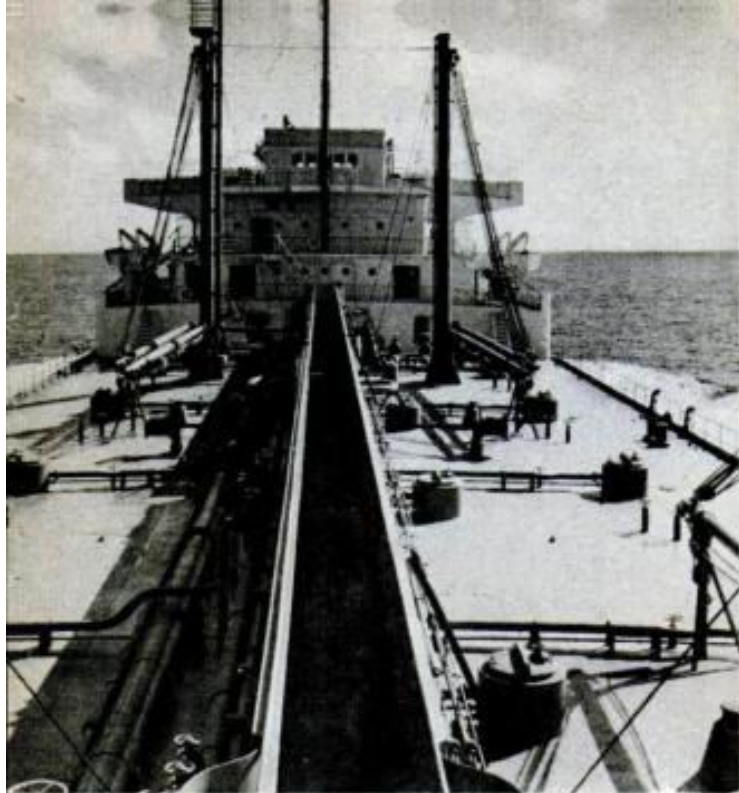
The TU-10 is manned by a crew of three—a pilot, a bombardier-radar operator and a crew chief who doubles as tail gunner. It compares closely in size and performance with the British-developed Canberra, which is being adopted by the U. S. Air Force but is not yet in production.

END

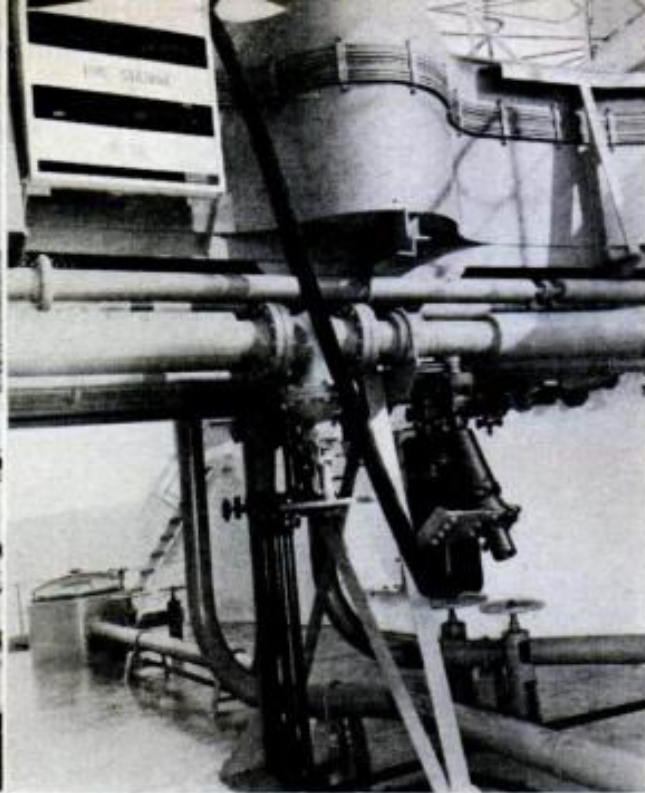


New Red attack plane hits 580 m.p.h.

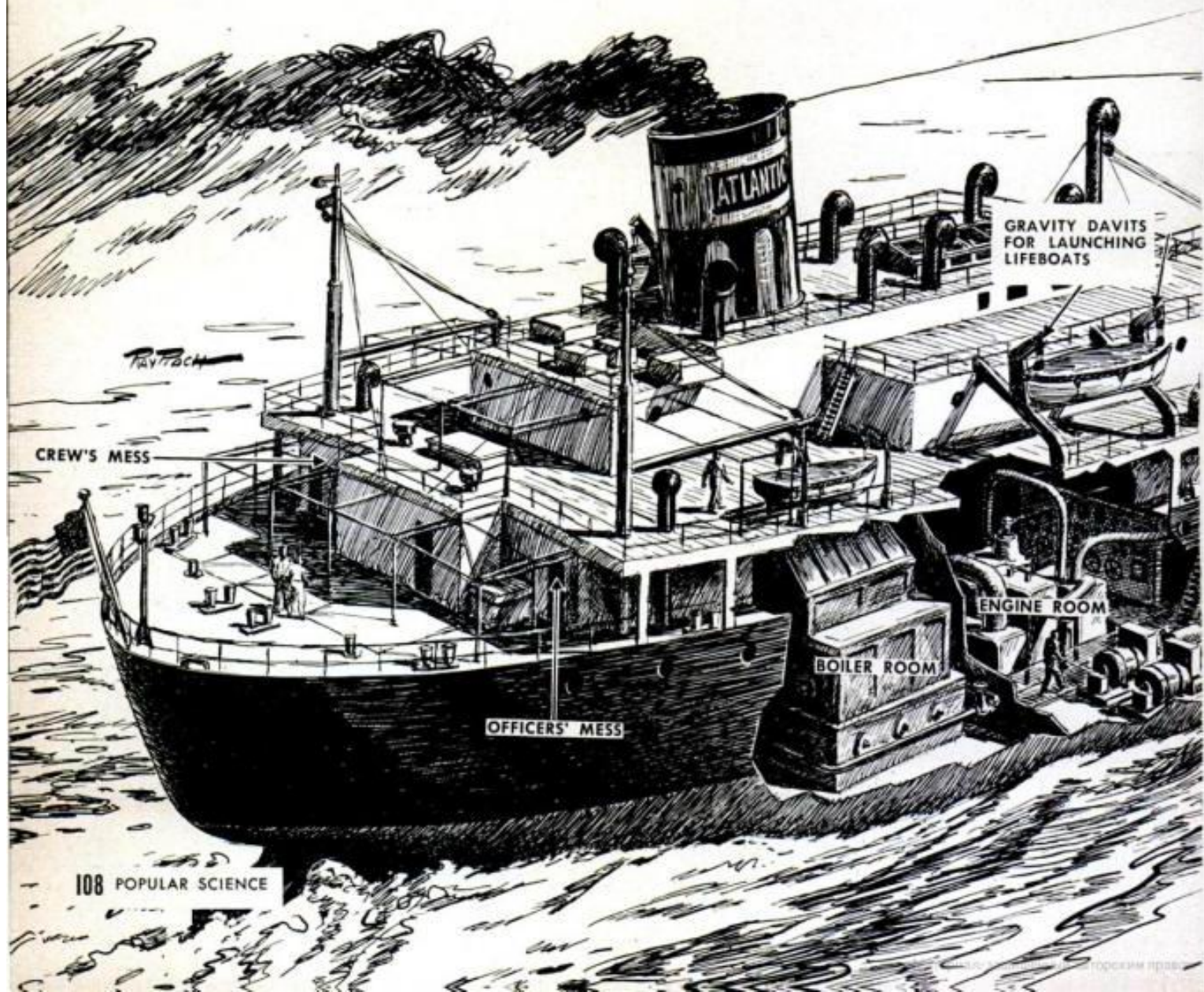




Catwalk, looking toward after housing from bridge, has stainless-steel sides that carry electric cables running length of ship. Foam stations are set along it at regular intervals. Another walk joins bridge and forecastle decks.



Remote-controlled foam station, one of many throughout ship, can smother a fire with six inches of foam in three minutes. Tanker is first with complete, built-in foam installation (capacity 170,000 gallons) to guard against fires.



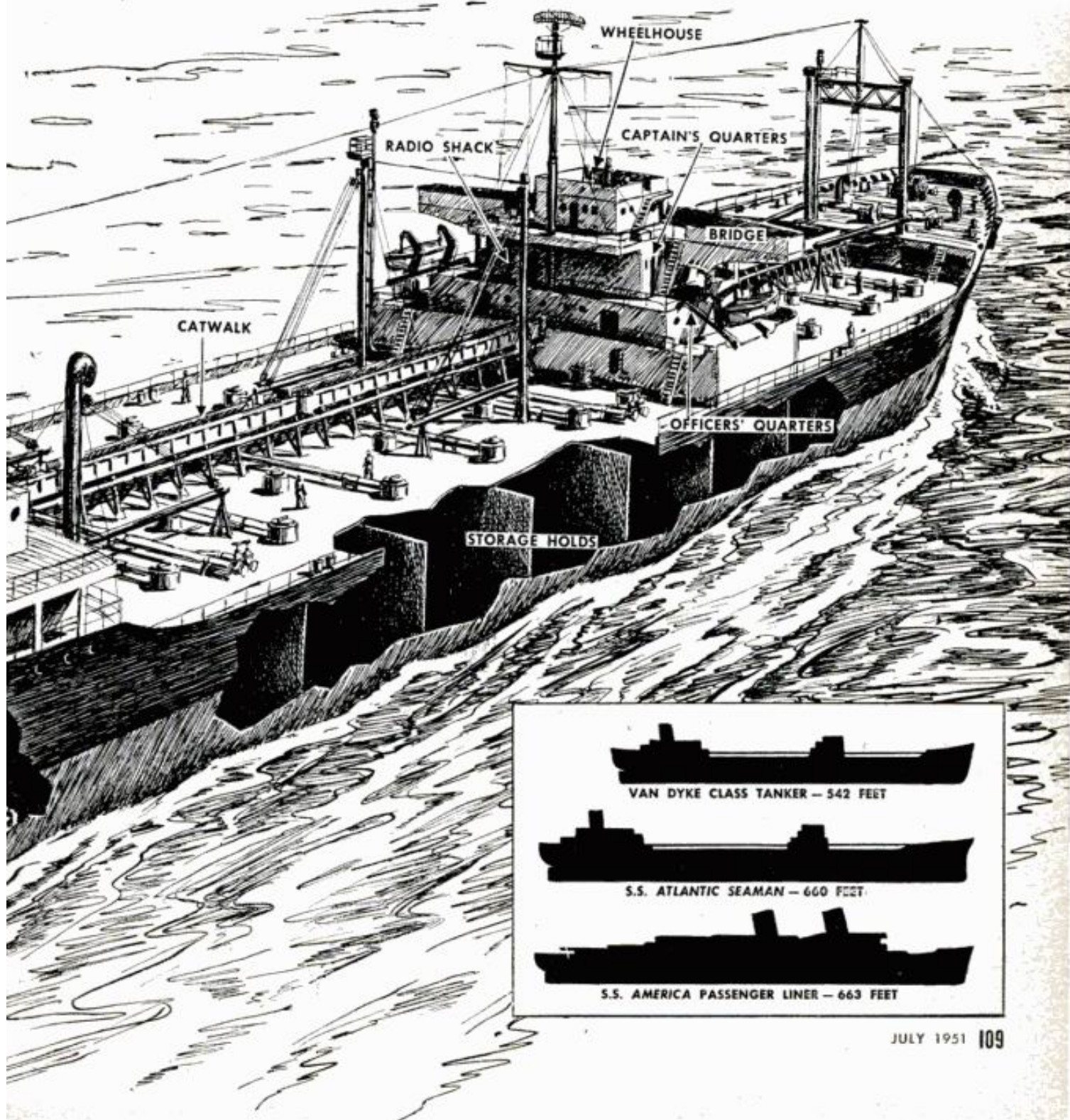
Largest Oil Tanker Totes 10 Million Gallons

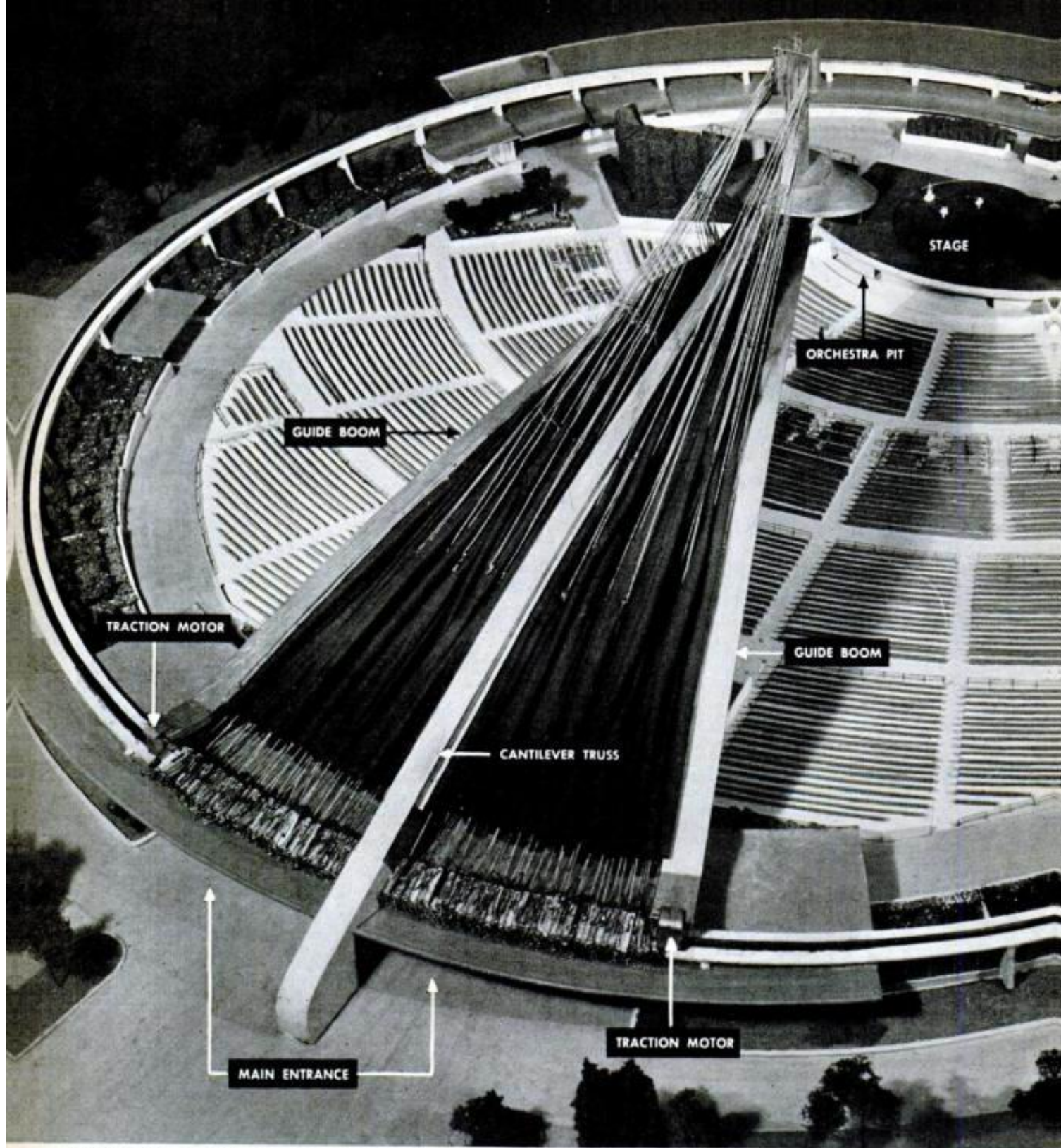
THIS is the largest, hottest, and one of the fastest tankers afloat, the S.S. *Atlantic Seaman*. Displacing 30,155 tons, she carries as much oil as a thousand tank cars. Filled with gasoline, she could give more than 16,000 motorists 10,000 miles of driving apiece.

The bigger the ship the less it costs per barrel to haul oil in bulk from foreign fields.

The *Atlantic Seaman* holds 257,935 barrels—10 million gallons. On her maiden voyage, the tanker averaged better than 18 knots. Her steam turbines, designed to develop 18,000 shaft hp., use the hottest steam of any ship on the seas—1,020°F.

Built by the N. Y. Shipbuilding Corp. for the Atlantic Refining Co., she has now been joined by two sister ships. END





Architect's model shows cantilever truss extending to center of amphitheater high above

the audience. Steel booms pulling the leading edges of roof will be propelled by two 50-hp.

The central control booth, suspended from the cantilever beam, will house operating mech-

anism for the roof, as well as sound and lighting equipment for the stage.

130 POPULAR SCIENCE





motors running on the 1,200-foot track mounted on a wall surrounding the theater.

Dual-cable system to protect against wind damage is shown below. Upper cables support

Moving Roof Covers Theater

Showers won't dampen the enjoyment of music lovers attending performances in this unique open-air theater.

By Richard Giovine

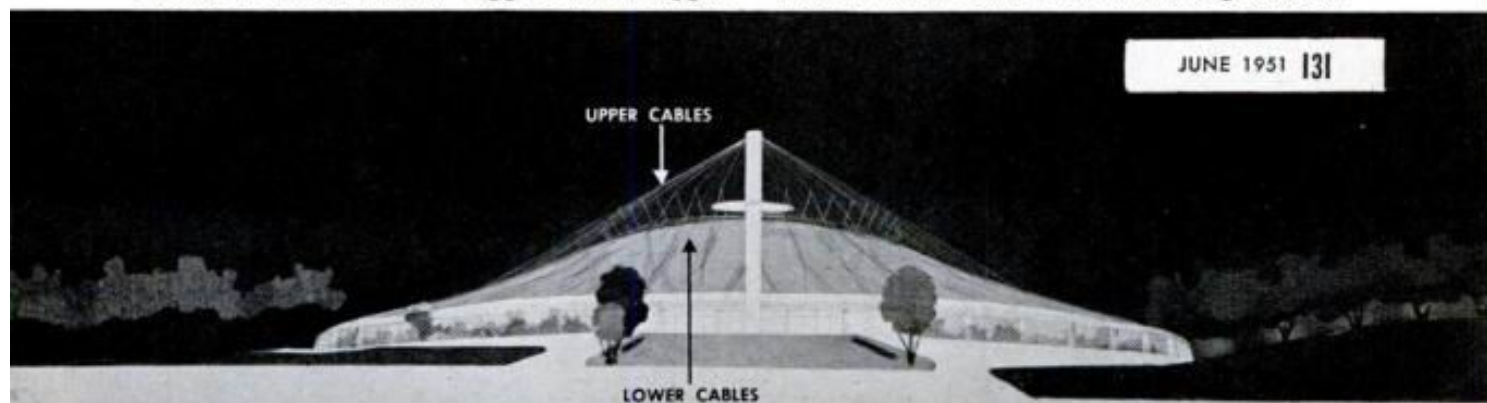
THE world's largest umbrella may soon provide rain-insurance for music lovers attending outdoor performances of the Pittsburgh Civic Light Opera Association.

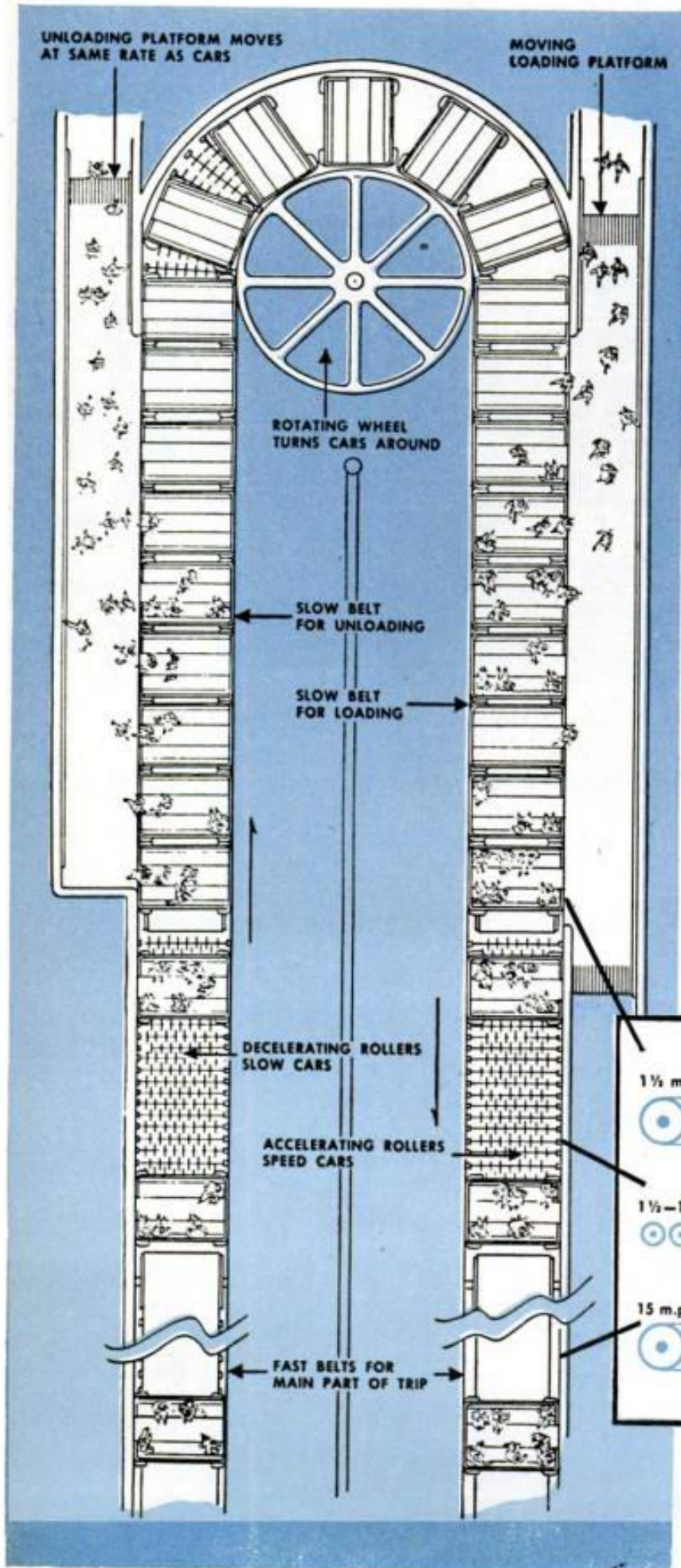
To solve the problem of costly rain-outs experienced in its present stadium location, architects have designed this unique amphitheater seating 9,500 people. It has a flexible plastic roof that will fan out to a diameter of 370 feet and cover the entire audience and stage within less than three minutes after black rain clouds begin to gather.

A giant cantilever steel truss, extending from the rim of the theater bowl, will terminate high above the crowd in a center mast to which supporting cables are attached. Traction motors, mounted on a track running along the top of the surrounding wall, will pull and guide two rigid booms that are secured to the leading edges of the fabric. A 15-foot-wide circle of gardens will catch rain running off the plastic roof. When not in use, the roof will be folded out of sight of the audience over an area to be used as a main lobby.

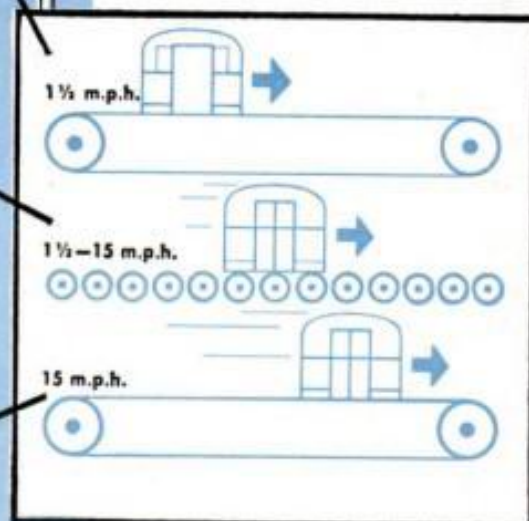
The idea was conceived by a firm of Pittsburgh architects, Mitchell and Ritchey, who say that actual construction now awaits the availability of materials. The project is expected to cost about \$1,750,000. **END**

dead weight of roof and resist outside winds. Lower cables resist internal wind pressures.

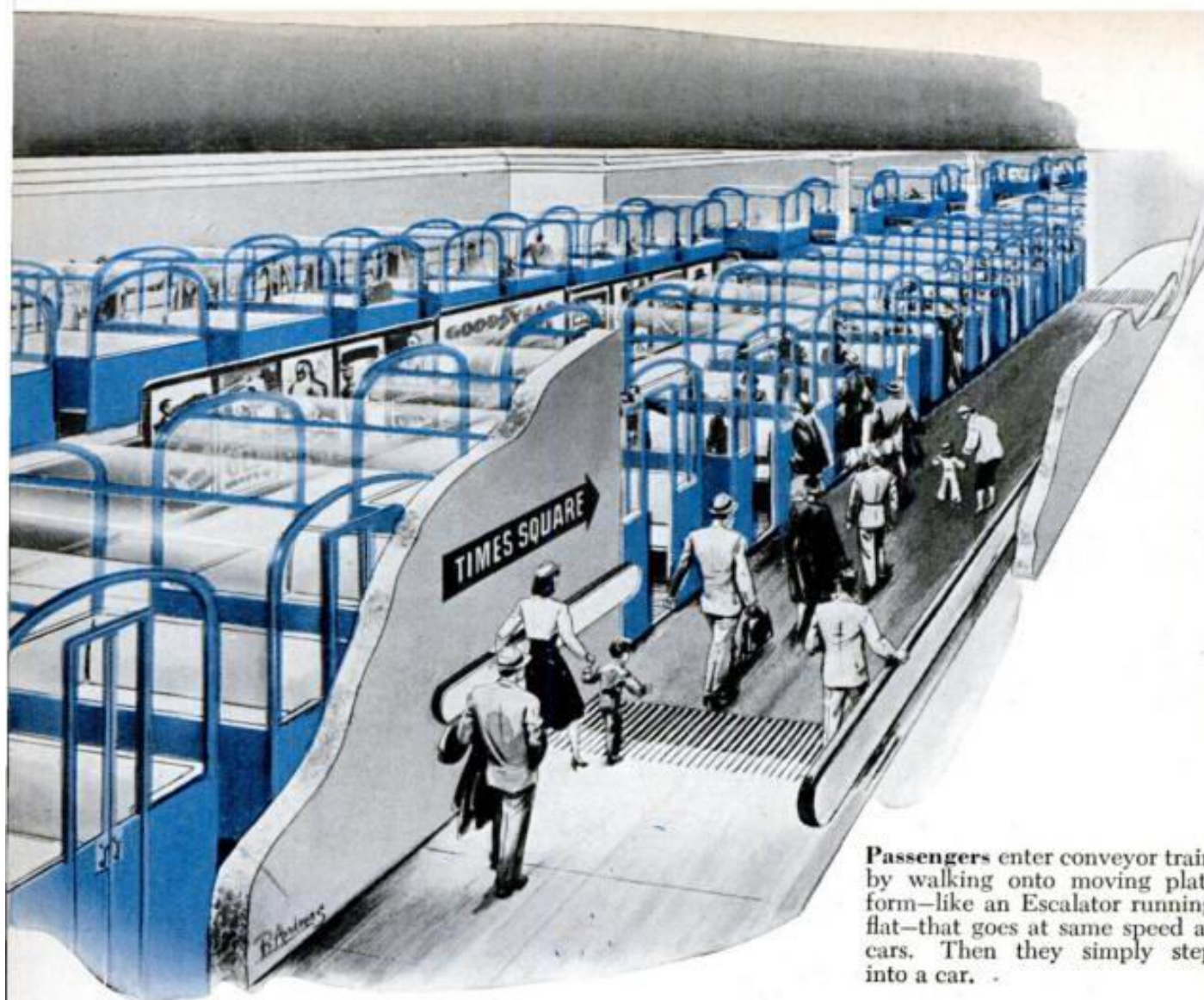




Endless Train



Car starts out slowly, is speeded up by rollers turning at ever-faster rates to reach the high speed of main-line conveyor. Thus, fast trip can be made safely.



Passengers enter conveyor train by walking onto moving platform—like an Escalator running flat—that goes at same speed as cars. Then they simply step into a car.

to End New York Subway Jam

CARS riding an endless belt could carry more than 500 people a minute across the world's biggest city. Plans for them have been submitted to officials struggling with New York City's traffic congestion.

This new kind of subway train would never stop nor end. Passengers would enter its cars from a sidewalk moving a mile and a half an hour, which is slower than many moving stairways. The cars would speed up to 15 miles an hour for the trip. At the end they would slow down and be turned around by a constantly turning horizontal wheel.

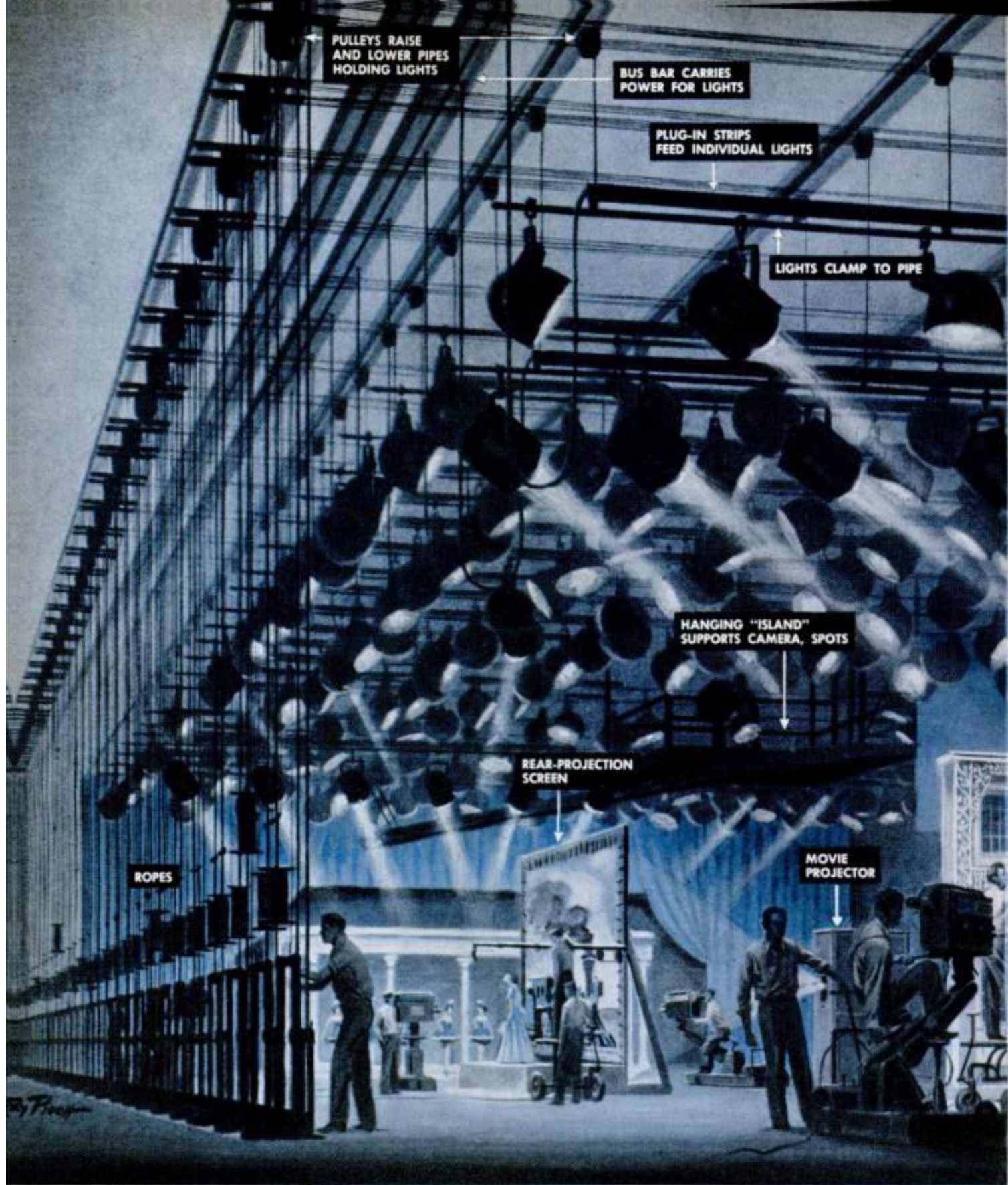
Although small, this train's many little cars could carry nearly twice as many people about a third faster than the crowds transported now by shuttle trains under 42nd St. between Grand Central and Times Square.

This shuttle is one of the worst bottlenecks in New York subways, and the mov-

ing-belt system was developed specifically for use there. Its designers, Goodyear Tire & Rubber Co. and Stevens-Adamson Manufacturing Co., say, however, that it could be applied to other subways. **END**



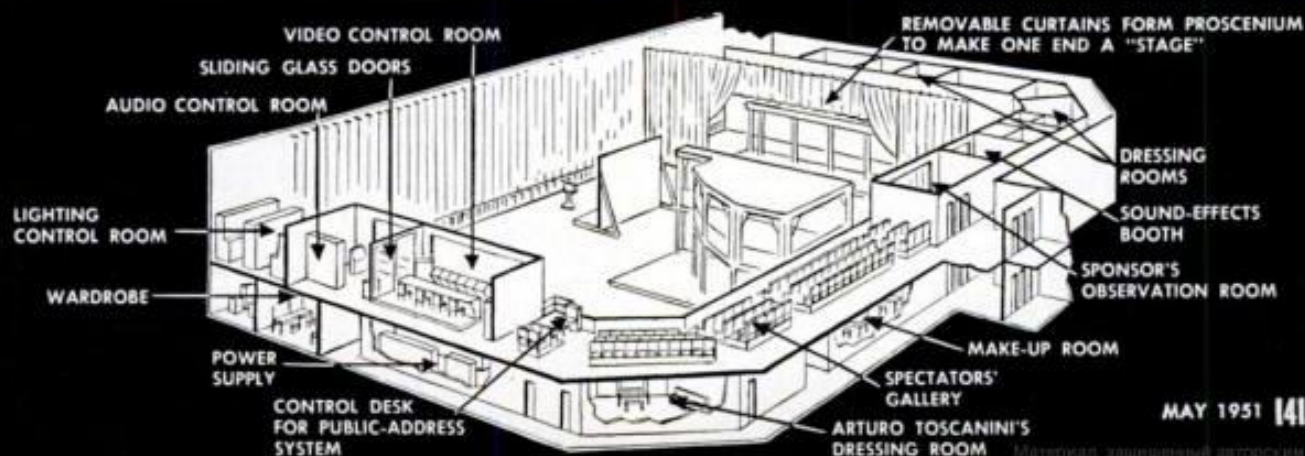
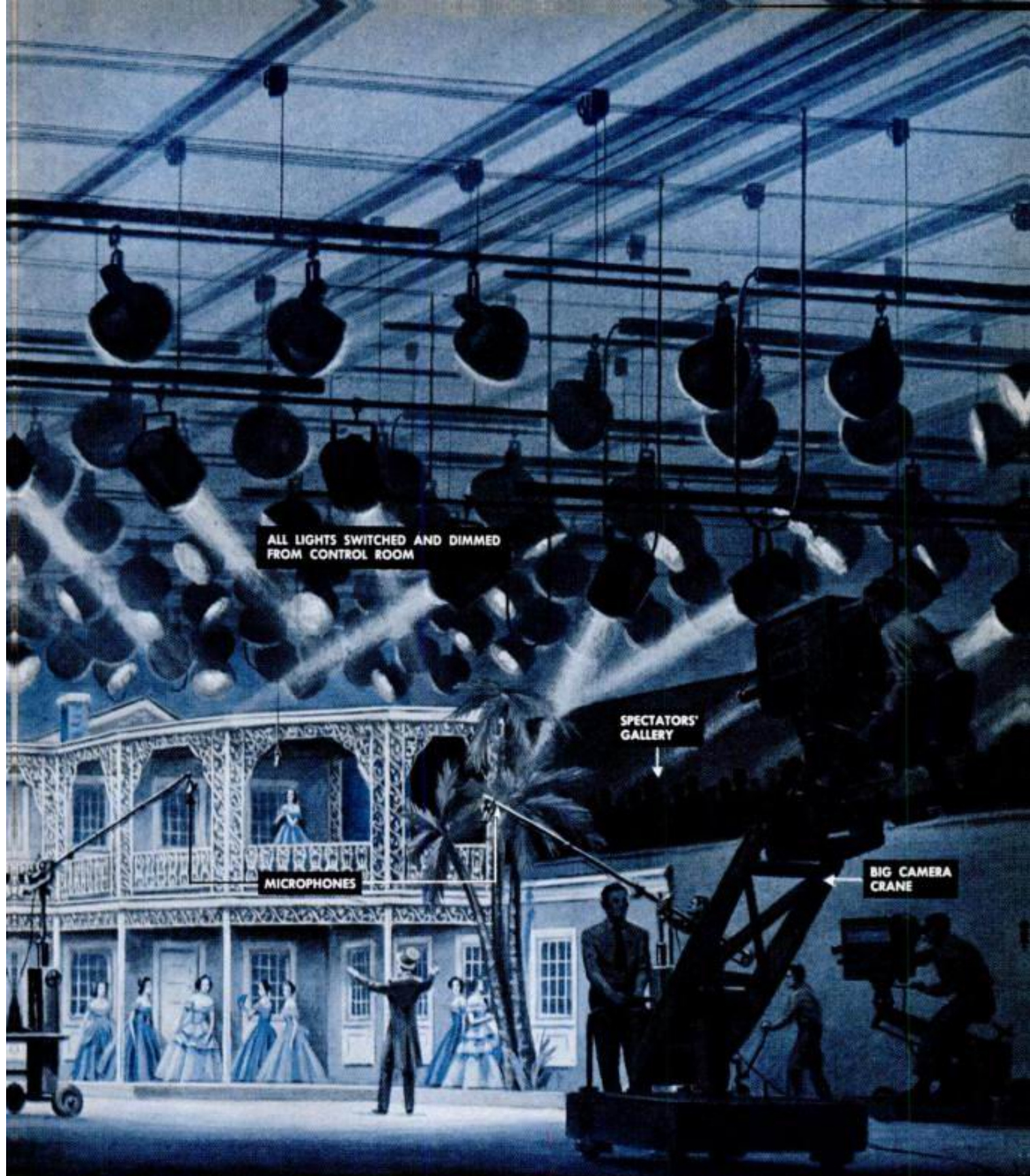
Proposed design for conveyor cars has clear-plastic top and sides. Automatic doors would be open only when car was alongside platform.



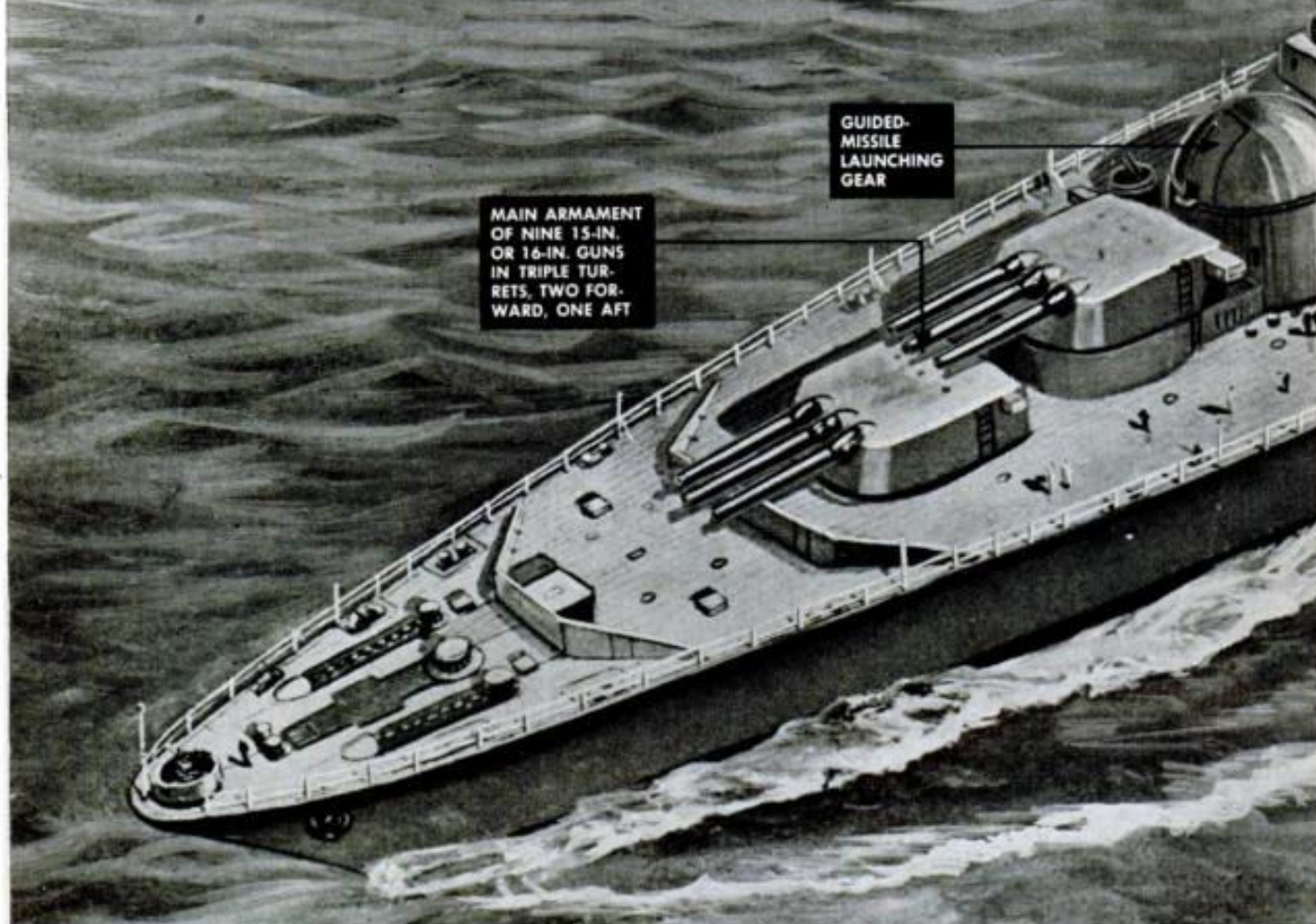
World's Biggest TV Studio

IT COST \$1,000,000, but Radio City's huge Studio 8-H has now been converted into the world's biggest and fanciest television studio. It is three stories high, 76 feet wide, and 130 feet long, accommodating several sets, six cameras—including one in an "island" hung from the ceiling—and 1,000 lights.

DRAWINGS BY RAY PLOCH



Does Russia Have This Mystery Ship?



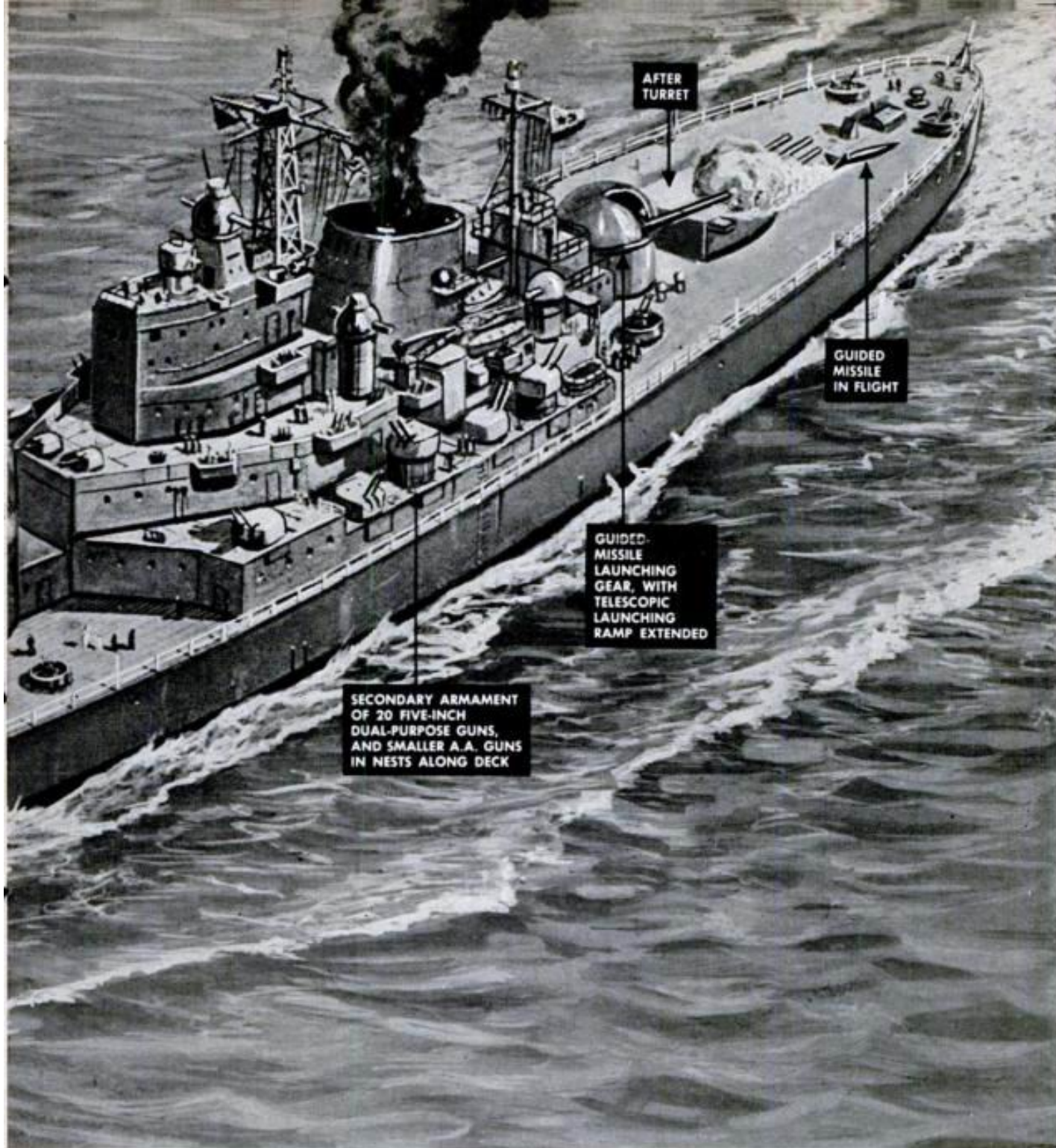
DOES Russia have new battleships firing guided missiles as well as shells?

In the picture above, a British naval artist sums up a crop of rumors that have reached the Western world of Soviet mystery ships. According to these:

A new Russian class of battleships consists of three sister vessels for service in the Baltic and Black Seas. One laid down at Leningrad in 1939, the *Sovietski Soyuz* (Soviet Union), suffered German bomb damage during construction and may still be unfinished. But two more being built at Archangel, the *Strana Sovietov* (Coasts of

the Soviet) and *Sovietskaia Byelorussia* (Soviet Byelorussia), may now be completed.

The new Soviet type, the rumors say, is a 45,000-tonner of more than 200,000 hp., with a maximum speed of 33 to 35 knots. Its armament includes a main battery of nine 15- or 16-inch guns, secondary armament of 20 five-inchers for use against surface craft or aircraft, and smaller antiaircraft guns. So far the description of the mystery ships closely resembles that of the largest U. S. battleships—the 45,000-ton, 16-inch-gun *Iowa* class. But the Russian ships are said to be shorter, 860 feet; wider, with a

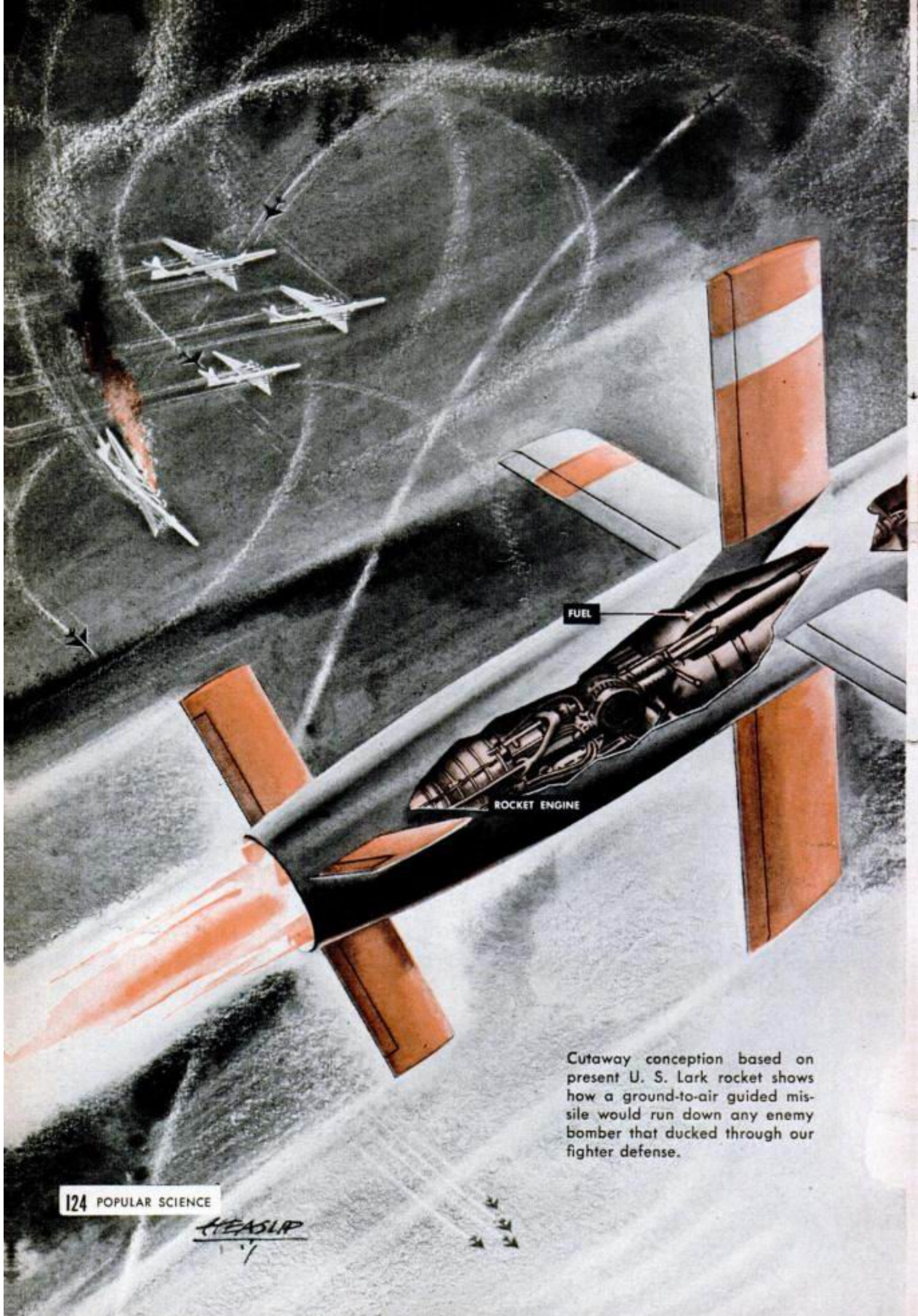


130-foot beam; and shallower, with a 29-foot draft.

They are also said to have one outstanding novelty—a pair of domed launching towers for guided missiles, which would extend the range of bombardment and might conceivably have atomic warheads. Such equipment has no counterpart in the world's capital ships as yet. (Pending guided-missile development, work has been suspended on the unfinished U. S. battleship *Kentucky* and large cruiser *Hawaii*, which were to have been armed with missile launchers instead of big guns. However, a current U. S.

program includes converting a heavy cruiser into a guided-missile ship for use "primarily against aircraft.")

The figures and speculation about the Russian ships may or may not be correct. Verified information is difficult to obtain this side of the Iron Curtain. But battleships are sizable things to try to conceal—and at least once before, rumors about them turned out to be right. These told, before World War II, that Japan was secretly constructing the biggest battleships ever built—the monster 63,000-ton *Yamato* and *Musashi*, sunk by U. S. carrier planes. **END**



FUEL

ROCKET ENGINE

Cutaway conception based on present U. S. Lark rocket shows how a ground-to-air guided missile would run down any enemy bomber that ducked through our fighter defense.

HEADUP
1/1



Missile's Mission: Picking Off the Strays

**Knocking down tomorrow's sneak A-bomber
is a job for a flying torpedo with built-in
radar eyes and its own vacuum-tube brain.**

By William S. Friedman

DRAWINGS BY WILLIAM HEASLIP

BEFORE Hiroshima, a lone enemy plane was hardly worth an air-raid alarm. Tomorrow, that single plane—a stray or a lone wolf depending on surprise—could be the one with the A-bomb. The vital need to pick him off short of his target is one of the reasons our defense planners are grooming a growing stable of guided rocket missiles.

Their big difference from the conventional rockets and antiaircraft projectiles used in Korea is that these birds with vacuum-tube brains can *change course* after take-off. Can follow a speeding target and blow it out of the sky, no matter how it tries to turn away.

For an idea of what it takes to do that at bullet speed, take a look inside the Lark—as sketched at left.

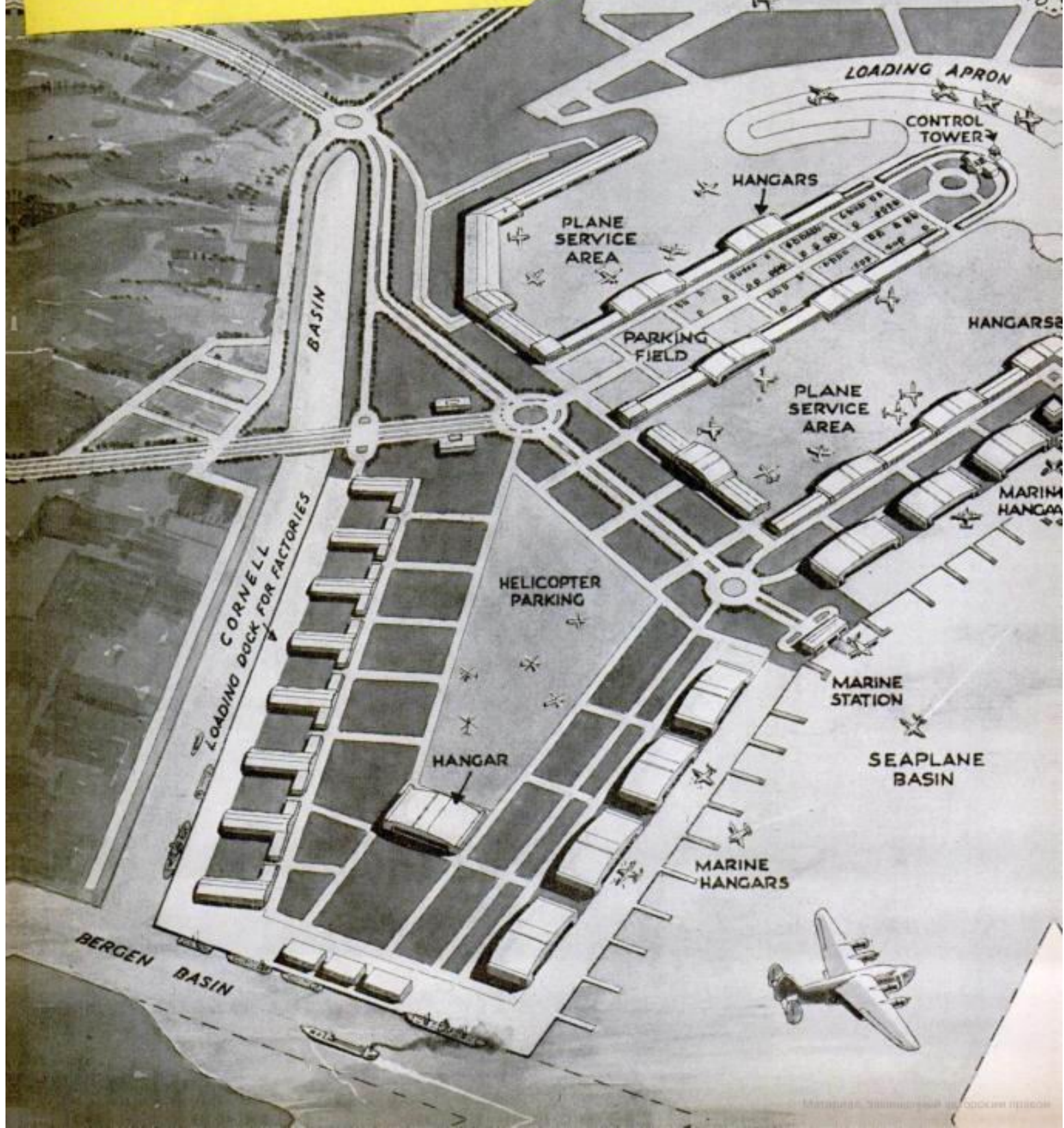
This ground-to-air torpedo is not the newest of our guided missiles: others, still under wraps, include slim supersonic killers for launching from planes. But the Lark is the one we can talk about now, and it's probably the one with the longest history of flight-tested modifications. Fairchild Engine and Airplane Corp.'s Guided Missiles Division, Farmingdale, N.Y., recently received orders to turn out the latest version for all three services—Army, Navy, and Air Force.

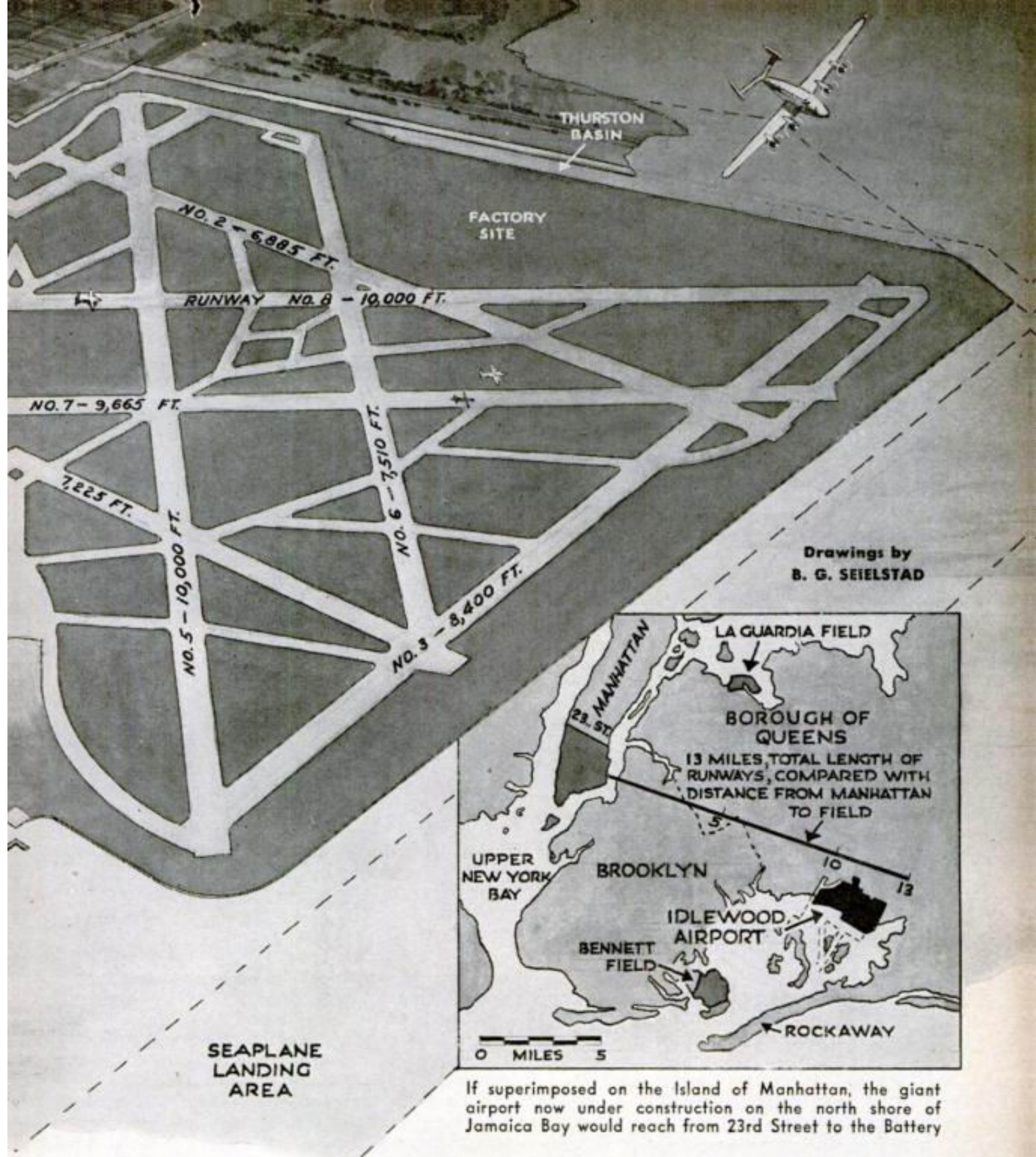
Today's Lark is a lineal descendant of the XSAM-N-2a, an antiaircraft missile developed late in World War II to knock down

World's Greatest Airport

TO SERVE SKYWAYS OF TOMORROW

New York City's new municipal airfield, now under construction, will be the port of nearly 1,000 flights a day, handling both passengers and freight for Europe, South America, and the West Coast.





A GIANT skyways depot containing the whole pattern of future air transportation is taking shape on our eastern seaboard. It's destined to be the world's biggest and most modern airport—a formidable adjunct to America's bid for postwar aviation supremacy. Yet so quietly is it progressing that few know of its whereabouts, let alone its size or significance.

This is the second aerial wonder project of New York's Mayor F. H. La Guardia and his city planners. Just 10 miles to the north,

across the Borough of Queens, the first great municipal field bearing his name handles more traffic than any other city airport in the land. It was regarded as mammoth when opened three years ago; but the new airport, with its 2,576 acres, has five times the area, and its design for traffic may turn up the clock a decade.

Some of the Mayor's predictions:

"Scheduled flights that begin or end at the new terminal will reach the staggering total of 950 daily. They will include landings and